COLOR WORKBOOK

Becky Koenig

fourth edition

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Illustrated by Becky Koenig

PEARSON

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Library of Congress Cataloging-in-Publication Data is available on request from the Library of Congress.

10 9 8 7 6 5 4 3 2 1

ISBN 10: 0-205-25594-9
ISBN 13: 978-0-205-25594-8

Instructor's Review Copy
ISBN 10: 0-205-25595-7
ISBN 13: 978-0-205-25595-5

à la carte
ISBN 10: 0-205-25715-1
ISBN 13: 978-0-205-25715-7

PEARSON

To my father, James R. Koenig, who introduced me to the world of color, and my mother, Catherine Catanzaro Koenig, who taught me how to teach, work, and listen.

Contents

Preface

Color is at the center of our strongest sense, vision. Color, in nature, influences our daily lives through our visual sensory input of skies, flowers, trees, stones, and water. Color is produced by the light that we experience in the course of days and seasons: cloudy, overcast, wintry, hot and steamy, sunny, clear and cool.

We reflect the colors of nature through our art, architecture, clothing design, electronic/ graphic design, and functional objects. Color guides our preferences in the appreciation of aesthetic objects and the acquisition of functional items for our daily living: cars, color in the interior of our homes, clothing, and food.

Color is both a physical and an emotional human phenomenon. We respond to color because of its associations. Each individual has personal preferences for unique color combinations. Our experience of the world can be characterized by our observation of color: a green apple, a red sports car, the pink sky of a sunset, the blue of a robin's egg. These colors evoke not only an outward experience but also form colors in our memory, our inner eye. Color is not simply a decorative element in art, but a part of our inner consciousness. Color is life enhancing.

For the artist and designer, color has the deepest complexity of any art element as well as being the most powerful and visually compelling formal and emotional factor in art creation. Color can soothe, disturb, express personality or culture, suggest or reflect reality, convey light or dark moods and emotions. Our personal color preferences may be rooted in our life experience, the collective unconscious, our physical surroundings, and our instincts. Color is unique among the art elements because it crosses the boundaries between art and science. Some of the information presented here may seem scientific to the student of art, but this is an essential link between contemporary art, design practice, and electronic technology. The scientific and technical content of this book also enhances a fuller understanding of color phenomena.

Color study is an undertaught yet ever-evolving field. There is now more color in our lives than ever before. More publications are produced in color, due to the ease of digital photography and printing. Web design is essentially illuminated pixels of color. There are also more color choices available to the artist than ever before, new color media and pigments along with the capability of digitally producing upward of 280 trillion colors. Due to technology, the arena of color in art and design has virtually exploded. The expansion of the role of color in art and design requires artists and designers to have a high degree of color knowledge.

Color study is a misunderstood area of art. Artists often harbor preconceptions about color, either as being a simple concept or a subject that is overly complex. Color study is often viewed as knowledge that hinders or inhibits the instinctive use of color. This is emphatically untrue. The study of color cultivates an innovative approach to color and helps us to avoid choosing colors in a simplistic manner, such as from a default computer swatch palette or directly out of a tube of paint.

Why another book on color? During my twelve years of teaching color theory, I used various texts, most of which only covered portions of color and design information that was useful to students. This led to my decision to put together a text myself. I wanted to represent color theory in a coherent manner and focus on the impact of color upon formal design. The color study activities in this text have been developed over years of teaching color theory in an ongoing pursuit to formulate experiential color study for students. In recent years, I have combined both formal and content-oriented approaches to color with students, allowing them to use color both technically and as an expressive tool. The Fourth Edition of *Color Workbook* includes an expanded Chapter on Digital Color, more activities in many of the chapters, revised illustrations, chapter learning objectives and glossaries for each chapter. There are digital activities on the technical side and more creative, thoughtful hands-on activities for the study of color as well. All of these improvements are meant to enhance the workbook approach to active learning, meant to expand knowledge beyond simply reading the text, into actual art- design experience.

In this book, Part One is a complete color-study section, covering color basics, color theory and systems, attributes of color, color materials, and computer color. In Part One, color is addressed as its own entity independent of compositional concerns. Part Two pertains to design, compositional theory, and the role of color in design, concept, and art. The two parts are meant to form a systematic journey for the student through color and design knowledge.

A primary factor in color and design knowledge is to allow students the experience of putting theory into practice. Hands-on study in color and design is invaluable. We cannot learn to be artists by simply listening to lectures or reading books. The point of the chapter activities is to make design and color theory accessible to all students.

This text can also serve as a self-guided tour of color for a dedicated student or artist. Even a sampling of the activities would be extremely helpful to a student's understanding of color. *Color Workbook* provides a broad base of knowledge that demystifies the complex world of color.

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Acknowledgments

Assembling this book has been a process enhanced by both professional and personal support.

I will always be grateful to the late Bud Therien, the editor for the first edition, for his patience, understanding, and belief in this project. The editor of subsequent editions, Amber Mackey and Billy Grieco, the current editor, have both been very helpful, involved and understanding. Thanks to Jessica Parrotta, editorial assistant, for her help with this 4th edition.

I would also like to thank the following reviewers for their critical input into the first edition: Douglas Latta, Oral Roberts University; Ken Burchett, The University of Central Arkansas; and Richard C. Green, Eastern Arizona College.

I appreciate the support and cooperation of the Adobe® Corporation for permission to use screen captures and for its invaluable software. I also wish to thank Pantone® color systems and Color Aid® for their quality products and permission to use their product names.

Thanks to the administrations and colleagues at both Villa Maria College and the University at Buffalo for the use of student works. The role of my students in this book cannot be overstated. Many of the illustrations from this book are the result of my students' hard work and dedication. My gratitude is extended to all of my students, at both Villa Maria College and currently at the University at Buffalo, who inspired and graciously contributed to this book. This book would not have been possible without you.

Last, I would like to thank my friends and family for their unwavering support through this project. Thanks my sister Karen Koenig and my brother David Koenig, for their support and enthusiasm from the beginning. I am appreciative for the encouragement of my entire extended family as well.

My love of art, painting, and color began with my wonderful parents, Catherine Catanzaro Koenig and James R. Koenig, both fine artists. My mother was always understanding and supportive of my hard work, and this book is dedicated to the memory of both her and my father and the immeasurable gifts that they gave to me throughout my life.

My love and thanks to my children, Kate and Sean, who have been supportive of me in the many writing, illustrating and editing phases of Color Workbook. My special love and thanks go to my dear husband, George Emery, who has been both a sounding board and editor, and whose encouragement and love have helped to bring this idea into being.

Color Workbook

Part One
Color Study

Chapter 1

The Nature of Color
Color Physics and Perception

LEARNING OBJECTIVES

- For the student to understand the basics of color physics and perception through the theories of Newton, Goethe, and modern color theorists.
- The student will understand the two functional systems of color:
  - Additive, the color system of light and the basis of color perception and light-based media, with the primaries RGB
  - Subtractive, the system of reflected color and physical, pigmented media, based on the primaries RYB or CMY
  - The interrelationship of additive and subtractive color, and how the artist/designer uses both systems.

INTRODUCTION

Color truly exists in the eye of the beholder. Color is a human experience generated collectively by the eye and the brain. In the concepts of both light and substance, the art and science of color are completely interconnected.

The first half of this book is devoted to color study. *Color study* is an objective examination of the many aspects and attributes of color. Color study is also an active process to help the student assimilate color knowledge in a direct experiential manner. Each chapter presents activities to facilitate the student's hands-on experience of color study and enhance the information in the text. A precise knowledge of color permits the student to apply color to art and design in a formal or instinctive fashion. The study of color connects the arenas of visual art (aesthetics) and science (physics). For artists, a foundation in the physics of color is crucial for the comprehension of color phenomena and color perception.

Color has three important aspects. Color's *physical aspect* pertains to color physics and perception, covered in this chapter. The *psychological aspect* of color encompasses color psychology, expressive color, and color intuition, covered in Chapter 11. The *chemical aspect* of color refers to color media (traditional media: pigments, dyes, and inks, or electronic media: digital forms), discussed in Chapters 5 and 6.

The *physical aspect* of color is primarily known to artists through *subtractive color*, the system of surface color and colored substances. The subtractive color system demonstrates the way light reflects from and is absorbed into colored surfaces. Subtractive color also pertains to the physical colors of pigments, inks, and dyes and how colors are affected in the mixtures of these substances.

Of these three basic concepts, the *physical aspect* of color as it relates to the *chemical aspect* of color, namely, the interrelationship of color and light (the physics of color) to colored physical surfaces and materials, can be the most problematic for art students. Because artists traditionally use the chemical aspect of color through colored substances such as paints, inks, dyes, and colored surfaces, they often have difficulty conceptualizing color as light (additive color). The science of color and light seems to exist outside the realm of traditional art materials. Digital arts, along with art forms that use actual light, such as video, have made the additive color system an essential color mode for artists working in electronic media.

COLOR PHYSICS

Color physics is the science of color. Color has been explored, systematized, and interpreted throughout human history. Isaac Newton (1642–1727), the English mathematician and physicist, created a groundbreaking moment in his scientific exploration of

Figure 1–1 In 1676, Newton's experiment proved that color is a component of light. The seven distinct colors produced by the refraction of white light by a prism are called spectral hues: red, orange, yellow, green, blue, indigo, and violet.

color in 1676. In 1676, Newton projected white sunlight through a prism, and a spectrum of colors was cast onto a white surface. [1.1] A color spectrum appeared because a prism *refracts* light, bending the light rays and sorting the colors of white light into their individual wavelengths. The refraction of light into a color spectrum was a well-known fact in Newton's time, through rainbows, cut glass, prisms, crystals, art glass windows, and so forth. The unique feature of Newton's discovery was this additional step in the experiment, he then reprojected the entire spectrum back through a prism, which re-formed white light. From this seminal experiment, Newton concluded that the recombination of spectral colors into white light was proof that the individual components of white light are separate colors called *hues*. Newton's experiment definitively illustrated that color was a property of light, concluding that light was composed of seven distinct hues: red, orange, yellow, green, blue, indigo, and violet. [1.2] This discovery was so controversial in its time that Newton waited until 1704 to publish his findings, wherein he detailed his optical light theories in a complete volume entitled *Opticks*. The experiments of Newton led to the current definition of *color* as a visual sensation caused by the components of light either transmitted or reflected to the receptors in our eye.

By refraction, the components of light were identified by Newton as seven separate hues, which are known as *spectral hues*, *the spectra*, or *prismatic hues*. We are perhaps most familiar with the spectrum in the form of a rainbow. A rainbow appears in the sky as an ordered band of spectral hues refracted from sunlight by water droplets in the atmosphere. Even though the spectral band has soft hue transitions that are not clearly defined, Newton chose the seven specific hues in the spectral band as the principal hues. He also

Figure 1–2 The color spectrum as it appears when white light is refracted; the hues gradate into each other.

correlated these hues with the notes in a musical scale, one of the many analogies made between color and music that recur throughout the history of color. The color purple (red-violet) was also added by Newton to the spectrum to connect the spectral band to itself, thereby forming a continuous color circle. [1.3] Newton formulated the color circle as a scientific device to illuminate relationships between the spectral hues.

Electromagnetic Spectrum

As the continuation of the study of light and color continued, the white light containing all of the spectral hues was found to be a very small part of the *electromagnetic spectrum.* [1.4] James Clerk Maxwell (1831–1879), a Scottish physicist, presented the theory of electromagnetic waves in the 1860s. Maxwell theorized that visible light was an electromagnetic phenomenon. Wavelengths of light (color) are radiant energy that originates in sunlight. The electromagnetic spectrum represents the energy waves produced by the oscillation of an electric charge. Unlike other types of energy transmission, such as conduction and convection, electromagnetic waves do not need any material for heat transmission. Both light and radio waves can pass through space at great distances and allow us, for instance, to be able to perceive the light from a star. Electromagnetic waves are arranged in a spectrum that organizes waves of high frequency (short wavelengths) to those of low frequency (long wavelengths). The electromagnetic spectrum ranges from gamma rays to radio wavelengths as shown. The visible light spectrum is a small portion of the electromagnetic spectrum that we can actually see. "Infra" and "ultra" prefixes signify the wavelengths of the electromagnetic spectrum that are out of our visual range or capacity to see, such as ultraviolet light.

Figure 1–3 Newton attached the spectrum to itself to form a color circle. He added purple (red-violet) as an intermediate hue between red and violet.

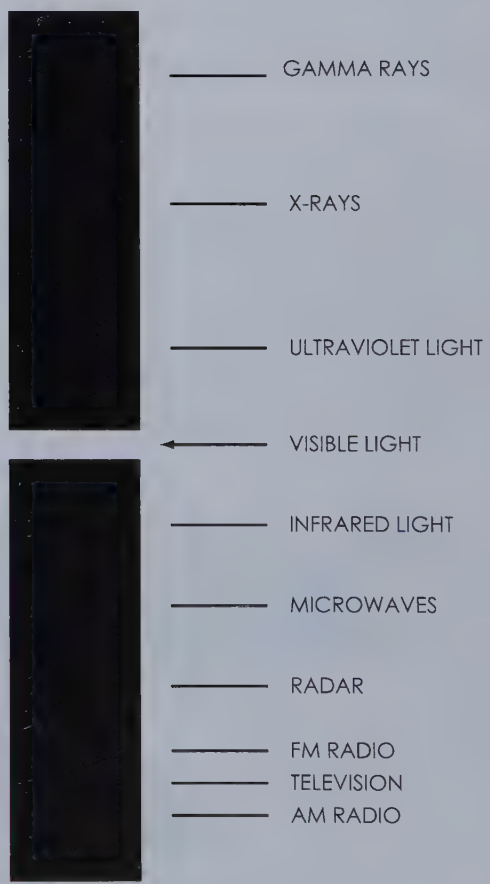


Figure 1–4 Of the entire electromagnetic spectrum, the only section that is visible to humans is the area of visible light, which includes the spectrum and color wavelengths.

Within the visible spectrum, each hue is individually defined by a specific wavelength. The wavelengths of light are measured in nanometers that are only one billionth of a meter. Each hue is visually unique due to variations in tiny measurements between the crests of each wavelength. Red has the longest wavelength and violet the shortest wavelength. Within each hue, we can also see subtle differences, such as a red that is more orange, or a yellow that is greener. White light, theoretically, is all seven spectral hues in equal balance.

PRIMARY COLORS OF LIGHT

The visible light spectrum represents the light that we see and all the hue wavelengths. Of the seven Newtonian hues of the light spectrum, there are three primary colors or essential hues that are necessary to form the full spectrum. *Primary hues* are hues that are the components of all the other hues and form all the colors that we see. The three primary colors for the formation of light are distinct from the three primary colors of paints: the *traditional pigment primaries* of red, yellow, and blue. James Clerk Maxwell identified the three *primaries of light* to be red, green, and blue, which we refer to as RGB. Maxwell based his theories, called the *trichromatic theory*, on the earlier research of Thomas Young (1773–1829) and Hermann Helmholtz (1821–1894). Young, a British physician, had proved that all colors were generated from the three spectral hues of red, green, and blue. [1.5] Helmholtz, a German physiologist and physicist, later expanded upon Young's ideas, and the two theories synthesized to form the Young-Helmholtz three-component theory. The three light primaries were determined to be the colors necessary to form all colors that we see because the color receptors in our eye correlate with these primaries. Maxwell presented the RGB additive perceptual hues in a color triangle. [1.6] The remaining spectral hues—yellow, orange, indigo, and violet—represent various intermixtures of RGB.

ADDITIVE COLOR SYSTEM

The *additive color system* is the color system relevant to colored light and our physiological color perception. Because light is the source of all colors, the additive system is the basis for all other color systems. When we see white, all the hue wavelengths are reflected or *added* together, hence the term *additive color.* This concept parallels Newton's recombination of the spectrum to form white light. In the additive system, when colored light is mixed, it becomes lighter and closer to white. For example, if the spotlights of

Figure 1–5 The primaries of light are red, green, and blue, or RGB. Notice that the primary red is a red-orange and the primary blue is almost violet.

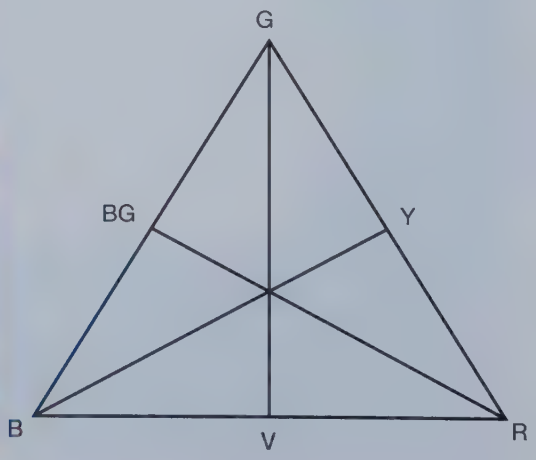


Figure 1–6 James Clerk Maxwell identified the three light or additive primaries as RGB and designed a triangle to demonstrate how they create all the colors.

Figure 1–7 The additive primaries, RGB, form white light when mixed together as colored spotlights. Mixtures of the additive primaries form secondary hues of cyan (blue), magenta (red), and yellow. The secondary hues of light are close to the primaries of pigment, and they are the primaries of process color.

the three light primaries, red (long wavelengths), green (medium wavelengths), and blue (short wavelengths), are overlapped, the result is white light as shown. [1.7] Thus:

Red + Blue + Green = White

In the trichromatic (meaning three-color) theory of light, RGB are the three source colors that combine to form all the other colors. Each additive light primary has its own character: The light primary red is rather red-orange, the light primary blue is quite blue-violet, and the light primary green is a slightly bluish green.

Color is perceived when the varied wavelengths of white light are selectively interfered with by matter; either absorbed, reflected, refracted, scattered, or diffracted and when our eye perceives one of these visual sensations.

The surfaces of colored objects either reflect or absorb one or more of the wavelengths of light. Understanding how RGB wavelengths either reflect off or are absorbed into colored surfaces clarifies the relationship between color and light. For example, we perceive a red surface because a red wavelength is the only light primary that is reflected back to our eye. The other light primaries, the green and blue wavelengths, are absorbed into the red (appearing) surface. The chemical makeup or colorant of the red surface causes the phenomena of absorption and reflection to occur. This illustration displays how light reflection and absorption causes us to perceive red, green, and blue, as well as black and white. [1.8] White reflects all of the primaries, which re-form into white light. Black reflects no light (all colors are absorbed), so we see a visual void, which is black.

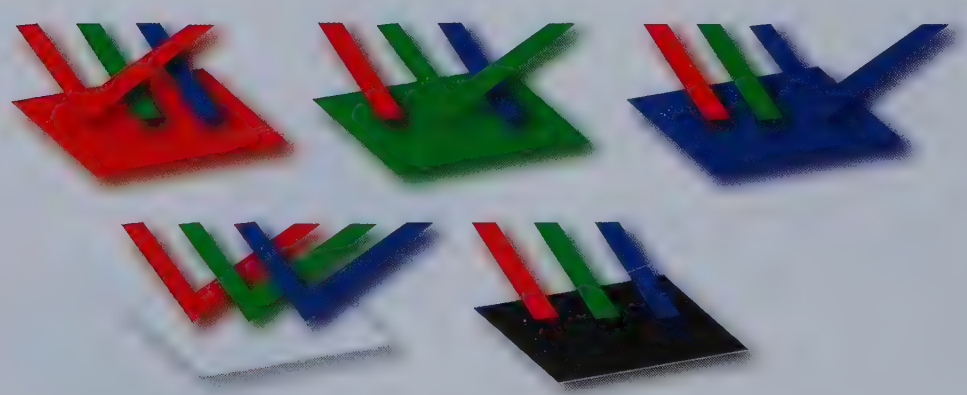


Figure 1–8 This illustration shows the primaries of light either reflected from or absorbed into colored surfaces, causing us to see color. When we see green, for example, both the red and blue light wavelengths are absorbed. The only wavelength reflected is green, which is received by the color receptors in our eye. With white surfaces, all the primaries are reflected; with black, none are reflected.

The additive primaries of RGB mix to create secondary hues. *Secondary hues* are defined as the mixture of two primary hues. The secondary hues of the additive system, cyan (blue), magenta (red), and yellow, are similar to the traditional primary hues of pigment, which we know as red, yellow, and blue. Cyan (C), magenta (M), and yellow (Y) are also process colors known as CMY. Process colors are the standard colors used in the four-color printing process and color photography. The light primaries mix to create cyan, magenta, yellow, and white as follows:

Blue + Green = Cyan
Red + Green = Yellow
Red + Blue = Magenta
Red + Blue + Green = White

The primaries of light, RGB, are shown here in an additive color circle with their secondaries placed between them to indicate additive color mixtures. [1.9]

COLOR PERCEPTION

Color is a uniquely human experience. Our visual system is designed to process the configuration of light on objects and support our human function and survival. The evolution of our color vision has a purpose; it helps us identify objects, food, and threats to our safety. Our vision is particularly acute in daylight situations when we are most active because we are not nocturnal. Our color vision is specific to light environments; it is much less effective in low-lighting situations. Vision is a human form of information processing; it is not a passive process. It enables us to act or react to the world around us.

We see color because our eyes are sensitive to a particular section of electromagnetic energy called the visible spectrum. A surprising aspect of color theory is that color actually is an illusion caused by reception of light wavelengths by our eye, which form colors in our brain. The colors can be created by several sources. Colors may also appear as a result of a phenomenon called *scattering*. For instance, the color of the sky is caused by the interplay of blue-light scattering from air molecules. Colors can also be a result

Figure 1–9 The additive color circle shows the light primaries RGB (outlined) in a circle format with the light secondary hues CMY, indicating how they mix.

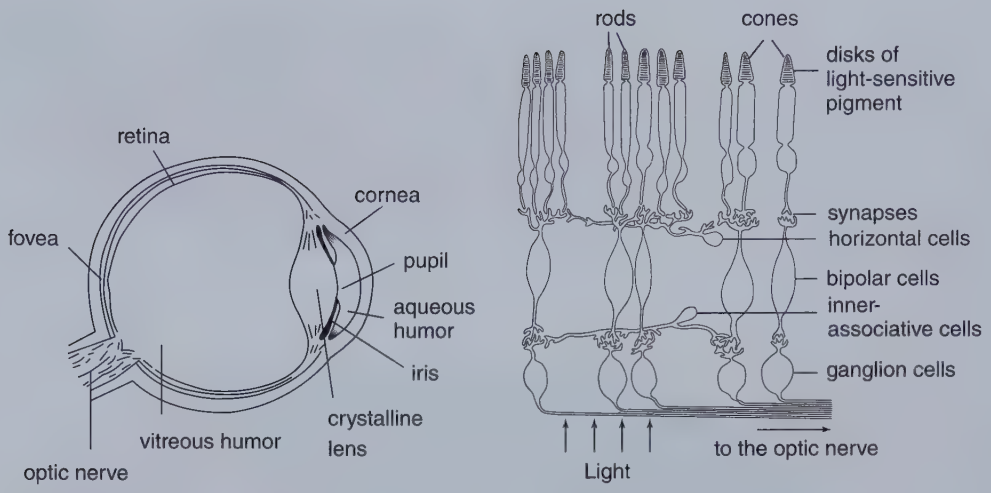


Figure 1–10 Color Perception. Our eye takes in color information through retinal cones, which have RGB receptors.

of incandescence, which is light created by heat/flame that consists of photons emitted when atoms and molecules release a portion of their thermal vibration energy. Other colors are the result of subtraction (the reflection and absorption of light wavelengths). For example, the yellow of a lemon is not a property of the lemon skin itself but is due to a lemon's capacity to absorb and reflect specific spectral elements from light, which our eye perceives as yellow. Yellow light, which is reflected off a lemon, is an example of residual light since it represents only a portion (the red and green wavelengths) of white light. Residual light is an information transmitter rather than a color. A color exists only if there is a person or animal to receive the light/color information being transmitted. Light rays are messengers of color information to our eye.

How do we receive light information to see a color? The human eye has two different types of color receptor cells. *Rods* are cells that help us perceive light/dark (value) differences and lighting strength, particularly in dim lighting situations. Cone cells are at the heart of our color perception; they selectively respond to specific colors. There are three types of cones: L red (long wavelength) cones, M green (medium wavelength) cones, and S blue (short wavelength) cones. [1.10] Each cone type is thus receptive to each of the additive or light primaries (RGB). Obviously, a green cone is stimulated by green light to produce the sensation of green in our brain. However, cones also work together in combination to produce all of the colors that we perceive. For example, as yellow light stimulates both red and green cones, the optic nerve transmits this information, and RG combine to form a yellow image in the brain. Cones are receptive to RGB hues but are only active in adequate light. For this reason, it is difficult to discern differences between hues at low levels of light.

A lack of green or red cones causes difficulty in the ability to distinguish between greens, yellows, oranges, and reds. This is called red–green color blindness. Color blindness is almost exclusively found in males since color genes are linked to the female X chromosome.

Visual information that we receive is broken into dots or patterns. It is then reformed in duplicate in our brain. We can also "see" a color mentally with our eyes closed during dreams, migraines, meditation, and the like. Factors that influence color perception include the following:

- The amount and quality of lighting on colored surfaces: natural or artificial, the level of light (as determined by the time of day and the weather)
- Our visual health, and/or the condition of color blindness
- The surface quality of the colored object itself: Is it shiny, matte, or textured?
- The source of the color: Is it reflective, transparent, atmospheric, iridescent?
- Color relationships: How is the color affected by its surroundings?

There is no color without light. Since color is a property of light, we require light for color perception. The type and quantity of light greatly affects our color acuity, as any given color will appear to change under varying lighting conditions. The same color will create a different color impression in sunlight, in half-darkened rooms, under fluorescent light, or in light from north- or south-facing windows. Depending on the time of day, light can vary in color temperature. Morning and evening light tends to have red or orange wavelengths, whereas midday sunlight is a cooler light. Thus, walls of the same color facing in different directions can visually appear to change in hue, value, and/or color intensity depending on the particular quality of light or time of day. [1.11] Many artists have made a study of varied color effects based on time of day or season.

There are two general categories of lighting, incandescent and luminescent. *Incandescent* light sources are a result of heated materials, the sun, fire, or the heated filament in an incandescent light bulb. *Luminescent* light sources are based on a chemical called phosphor, including computer screens, televisions, and fluorescent lighting. Incandescent light sources tend to be warmer in their color influence and luminescent lighting is somewhat cooler. There is also bioluminescence, in which activated electrons produce light in fireflies and some types of fish.

Even though we can see obvious color changes in different lighting situations, we possess something called *color constancy*. *Color constancy* refers to our ability to recognize a color, aside from its lighting conditions. This concept ties to our perception of objects as having a stable, fixed appearance. We know a red object, such as an apple, is red regardless of its appearance in bright sunlight or in a shadowy room. Thus, we connect our memory of an object to its known color identity.

Lighting is also a critical factor in an artist's studio. Incandescent light is warm, and fluorescent light is cool. Southern light is too changeable and warm in the Northern Hemisphere, so north-facing window light is preferred. Southern light is the preferred light in the Southern Hemisphere.

ADDITIVE COLOR MEDIA

The importance of the additive color system to artists has increased substantially over the course of recent years. Additive color used to be an interesting introductory scientific concept that was put aside as students worked with traditional art materials. Today, artists and designers must understand additive color because of its pervasive uses in video, electronic

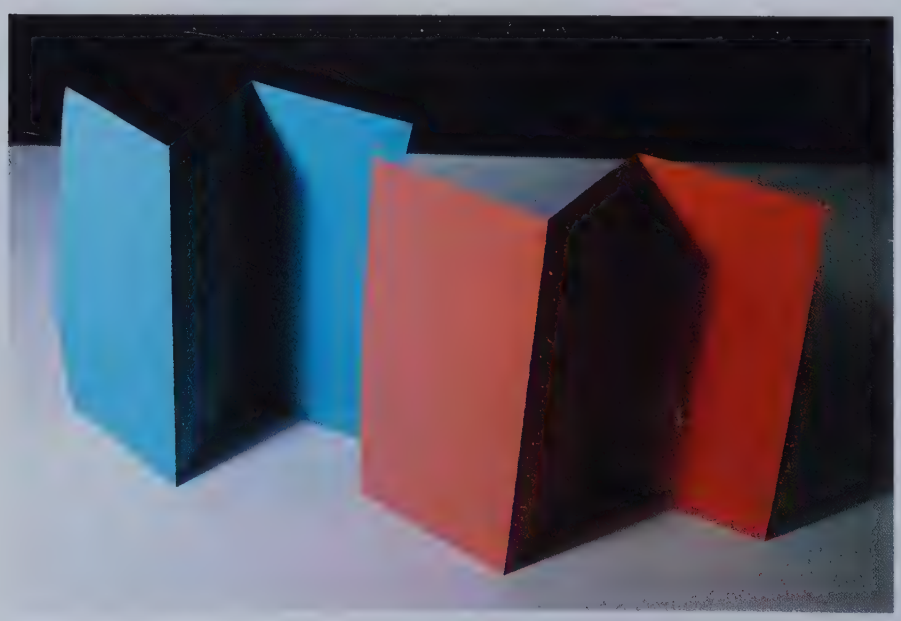


Figure 1–11 Quality and amount of light affect color. Note that the same surfaces appear to be different colors in light and shadow areas.

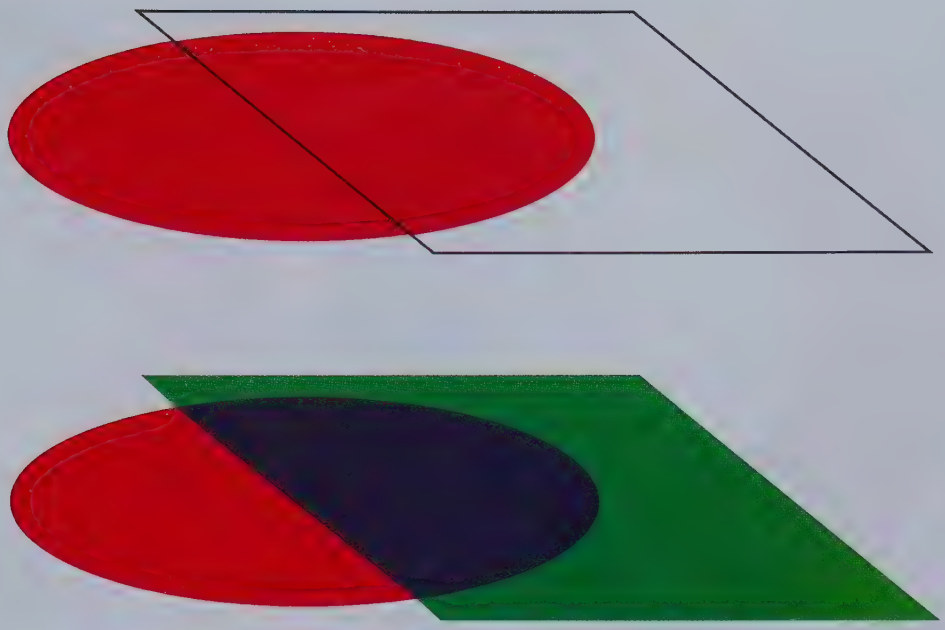


Figure 1–12 When a red light is directed onto a green surface, there is no green wavelength in the light to reflect, so the resulting color is black.

media, and lighting. Practical applications of the additive system of colored light include: television, digital media, web design, holography, light installations, and stage lighting. The additive color circle is also integral to photography, both digital and film.

Stage lighting utilizes colored light on colored surfaces to achieve dramatic and atmospheric effects. A lighting technician must understand the additive system to predict the effects of colored lights in combinations and their usage on various colored stage sets. Overlapping RGB spots will create a white spotlight. When a red light, for example, shines on a green area of a set, the resulting color is black. [1.12] We see black because the red wavelength is absorbed by the green surface, and there is no green light wavelength in the red spotlight to reflect green back to our eye.

Television color is generated from the three additive light primaries. Television uses tiny dots of projected RGB-colored light that visually mix to form a wide array of colors. Older cathode ray tubes are equipped with electron guns that project RGB dots onto the surface of the screen in varying proportions to produce colors and movement. Projected RGB light is fed through a mesh of dots or stripes to form a pattern on the inside of the screen. Newer display technologies include LCD screens. A liquid crystal display (LCD) is a thin, flat display device made up of a number of color pixels arrayed in front of a light source or reflector. Plasma screens work a little differently. Many tiny cells located between two panels of glass hold an inert mixture of gases (neon and xenon). The gas in the cells is electrically turned into plasma, which then excites red, blue, and green phosphors to emit light. If we hold a magnifying glass to the surface of a television screen, we can see an elaborate configuration of RGB dots.

Computer display monitors are capable of a much wider range of colors than television screens. Computer screen display color is also composed of combinations of RGB hues. The computer "thinks" in the additive RGB system when it creates or selects colors. The RGB system in a computer mixes colors in an additive manner and can be an aid in our comprehension of additive color mixing.

SUBTRACTIVE COLOR SYSTEM

While the additive color system pertains to intermixtures of light itself, *subtractive colors* are opaque surfaces that reflect light, rather than being source colors, such as light itself. The subtractive color system refers to surface colors and the physical colors of pigments, inks, or dyes. Subtractive color is defined as both the process by which we see

colored surfaces as well as the way traditional colored materials are mixed together. The *subtractive color system* describes the way light reflects from or absorbs into the colored surfaces of objects. For this reason, pigment colors or colored objects can be considered as "second-hand" colors. In the subtractive system, as hues combine, light waves are absorbed or *subtracted*, resulting in a reduction of the amount of light reflected to our eyes. The reduction of reflected light subtracts from the color intensity that we, in turn, perceive.

Subtractive color is an indication of the way that physical colors subtract intensity from each other when mixed together. The traditional way to alter or control colored surfaces is to use pigmented materials. As strange as this may seem to the artist, traditional colored media such as paint, inks, and dyes are not in themselves colored. The colored substances of art merely serve to reflect a specific colored light wavelength to our eye. Objects appear to be varied colors because of their differences in spectral composition and their ability to reflect light. Our brain creates the sensation of color by the absorption or reflection of light waves off colored materials to create color sensations on our retina. Surface color reflects or absorbs one or a combination of the three light primaries, RGB, as shown in Figure 1–8.

Subtractive Primary Colors

The subtractive system is the basis for the system of traditional pigment primary hues, red, yellow, and blue, and the process primaries, cyan, magenta, and yellow. [1.13] There are subtractive primaries that apply to two different types of media. The *traditional subtractive pigment primaries* for paints, inks, and dyes are red, yellow, and blue, or RYB. The *subtractive process primaries*, used in process printing, photography, and computer printing, are cyan, magenta, and yellow, or CMY.

The German poet Johann Wolfgang von Goethe (1749–1832) developed a color theory based on subtractive color surface perception and traditional pigment mixtures. The original intent of Goethe's color theory was to refute Newton's theories of color/light optics. Goethe identified the color primaries as red, yellow, and blue. He formed primary and secondary hues into both a color circle and triangular configuration. [1.14]

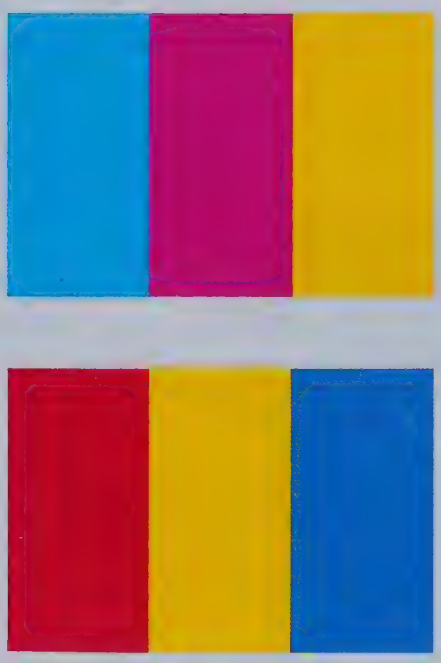


Figure 1–13 Top: Cyan, magenta, and yellow are secondary hues of the light (additive) system; they are also known as the process primaries of the subtractive system. Bottom: The traditional pigment (subtractive) primary hues are red, yellow, and blue.

Figure 1–14 The Goethe color triangle. Goethe formulated a triangular configuration of the subtractive primaries to indicate the secondary colors and complementary mixtures in areas beween the primary and secondary hues.

Figure 1–15 A simplified version of the traditional color circle or wheel. RYB are the pigment primaries and OGV are the secondary hues mixed from combinations of the primary hues.

Figure 1–16 Process Circle. A subtractive process color circle, in which the primary hues of CMY are outlined. The process colors also mix to create the secondary hues of orange, green, and violet.

Goethe's theories filled the gap between art and science that began with the theories of Newton. In the artist's perspective at that time, Newton's theories of light and color seemed to be unusable to artists engaged with pigment manipulation. Thus, there is a seeming disparity between additive light (color sensation) and subtractive surfaces (physical pigmented surfaces).

Secondary subtractive colors are the mixtures of two primary colors. Both sets of subtractive primaries, RYB and CMY, can be mixed to create secondary hues (different from the secondary hues of light). The *subtractive secondary hues* are green, orange, and violet as displayed on the two principal subtractive color circles: the *traditional pigment color circle* [1.15] and the *process color circle.* [1.16] Color circles are visual guides to color; one of their functions is to demonstrate how primary colors mix to make secondary colors. Subtractive primary hues mix to form secondary hues as follows:

Pigment Primary to Secondary	Process Primary to Secondary
Red + Yellow = Orange	Magenta + Yellow = Orange
Blue + Yellow = Green	Cyan + Yellow = Green
Blue + Red = Violet	Cyan + Magenta = Violet

In mixtures of paints or dyes, subtractive colors lose intensity because the light wavelengths reflected to our eye are decreased or subtracted. For example, when red and green pigments are mixed, the two hues tend to cancel each other out, forming a brown or gray. The mixture of all three subtractive primaries, RYB or CMY, creates a void, black, in which no light wavelengths are reflected. [1.17]

Theoretically, in paint, all the known colors can be generated from three subtractive primaries of RYB. In reality, pigments are rather unpredictable, which makes it a challenge to mix all the spectral colors from the same three primary hues. Several versions of the primaries are needed to mix "clean" secondary colors, or secondary colors can be purchased ready-made. Painters can obtain a much wider range of color without the limitations of only RYB pigments.

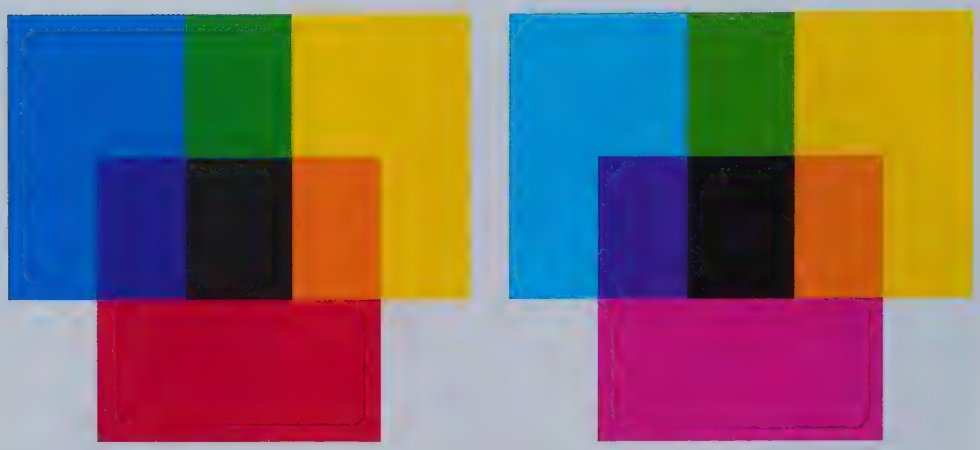


Figure 1–17 The subtractive primaries, RYB or CMY when mixed, form black, since no color wavelengths are reflected to our eye.

THE RELATIONSHIP OF ADDITIVE AND SUBTRACTIVE COLOR

The seeming incompatibility of the additive and subtractive color systems is precisely what confuses many color study students. The relationship between additive and subtractive color systems, however, is a clear inverse relationship. This integral relationship is as follows: The additive primaries (RGB) of light form cyan (blue), magenta (red), and yellow, the secondaries of the additive light system, which are also the process primaries of the subtractive color system. The relationship between the additive and subtractive colors can be clarified by the placement of hues on the color circles. A comparison of the additive color circle with the subtractive color circle will aid the student in the transition from one color system to another. (See [1.9] and [1.16])

Artists and designers should be able to comprehend and control both functional systems of color: additive (of light) and subtractive (of surface color and pigments). Often this causes confusion in the modes of color mixtures. Process colors (CMY) and the traditional pigment colors (RYB) mix with each other, for instance, in a manner that completely opposes the additive system. We know that the RYB primaries, when mixed together, will produce a black or gray. The theoretical RGB light mixtures directly

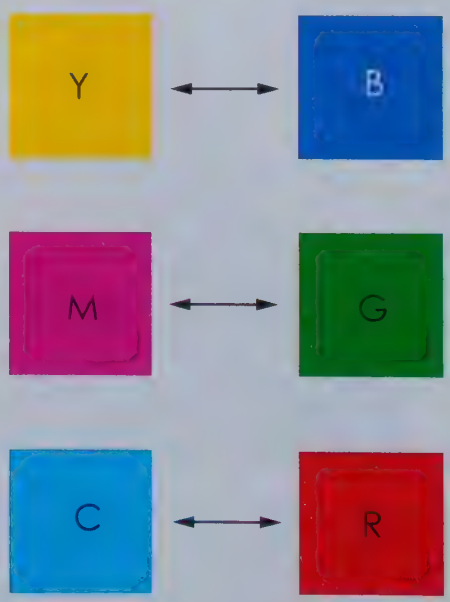


Figure 1–18 Additive Complements. Complementary colors are directly across the color circle from each other. Additive complements affect how we see colored surfaces since complements absorb the light wavelengths of each other.

oppose our experience of mixing paint as we know that paint colors of red, green, and blue, when mixed together, would not produce white as they do when RGB lights are mixed. On a digital device, however, RGB is being electronically mixed for every illuminated color that we see on screen.

For consistency, a major portion of this book has its foundation upon the traditional color circle. In discussions of photographic and electronic color, however, we must shift to the additive RGB color circle. Color printing and photography use the process primaries CMY to create a wide array of colors. The CMY mode on computers re-creates this process. Cyan, magenta, and yellow on the computer can be manipulated by percentage or by sliders to form a huge range of colors.

COMPLEMENTARY COLORS

In color study, the concept of color opposites or complements is significant. This relationship is particularly important to the phenomenon of subtractive color. *Complementary pairs* are composed of two hues located directly across from each other on the color circle. Refer to the additive color circle [1.9] to find the *additive complementary hues.* [1.18] In additive color the complementary pairs are as follows:

Yellow—Blue
Magenta—Green
Cyan—Red

A complementary relationship in color is that of two opposite components that complete each other in a type of color balance. For instance, a yellow and blue complementary pair from the additive color circle represents the hue primaries as follows: yellow (red and green) opposite blue. In this manner, all three light primaries are represented in each pair of additive (light) complements. The same principle holds true for the subtractive complementary pairs.

Additive complementary hue pairs absorb each other. Blue absorbs yellow light, red absorbs cyan light, and green absorbs magenta light, and each combination also absorbs in reverse, as shown below. The chart shown here [1.19] illustrates how complementary

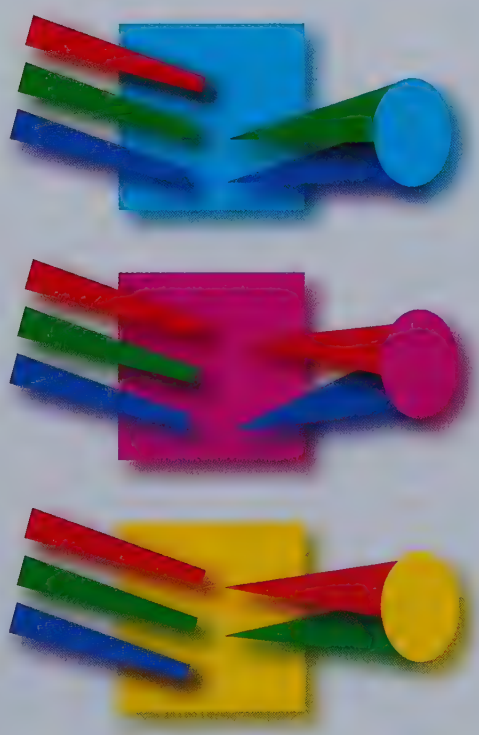


Figure 1–19 This illustrates how we see the subtractive surface color of CMY. The RGB light primaries are either reflected or absorbed in varied combinations to give us the appearance of cyan, magenta, or yellow.

Figure 1–20 In the photo of an apple, there are many more variations on red as well as other colors than in our symbolic image of an apple.

absorption and subtraction allows us to see the secondary colors of light. For example, the red light complement of cyan causes red to be absorbed into a cyan surface. Blue and green light primaries are reflected from this surface to create the appearance of cyan.

Thus, we see CMY hues due to additive complements as shown below:

Cyan absorbs red light—reflects blue and green light (C).
Magenta absorbs green light—reflects red and blue light (M).
Yellow absorbs blue light—reflects green and red light (Y).

LOCAL AND RELATIVE COLOR

Local color is the generalized color of an object under normal lighting (daylight or white light) conditions due to our sense of color constancy. Local color is a simple method of color perception and interpretation of a colored surface. For example, the sky is blue, an apple is red, and a lemon is yellow. Our mind tends to generalize color for object identification. For instance, we know that an apple is red even in a dimly lit room because of our color memory. In reality, a single apple may have many different colors: red, red orange, magenta or purple, and sometimes flecks of green, yellow, or orange. [1.20] Lighting, surrounding color highlights, and shadow areas on the apple create even more color variations. The surface quality of an object can also influence color perception. Is the observed object emitting light, like a computer or video? Does an object have a matte or glossy surface? Is it highly textured or reflective? These are all factors in color perception.

Colors are also perceived in context. In reality, we rarely see a color isolated on its own. Even if we see color in the context of a neutral color, such as black, white, or gray, that color is affected by its neutral surroundings. The red shown here on the white surface looks heavier, darker, and larger than the red on the black surface. [1.21] Red on a black surface appears to be lighter, more luminous, and smaller in scale than the same red on a white surface. When colors are presented on competitive terms with each other, more radical changes can occur. On an orange surface, a blue appears to be enhanced in color intensity. On a dark blue surface, the blue seems lighter and much less intense. Thus, our color perception is based on comparison and contrast. This concept is called relative color or *color interaction.* This concept is extremely important in the process of making art and design, as colors are almost always used in groups. The artist or designer needs to actively predict and control the color effects that occur as a result of color interaction, which is explored in detail in Chapter 4.

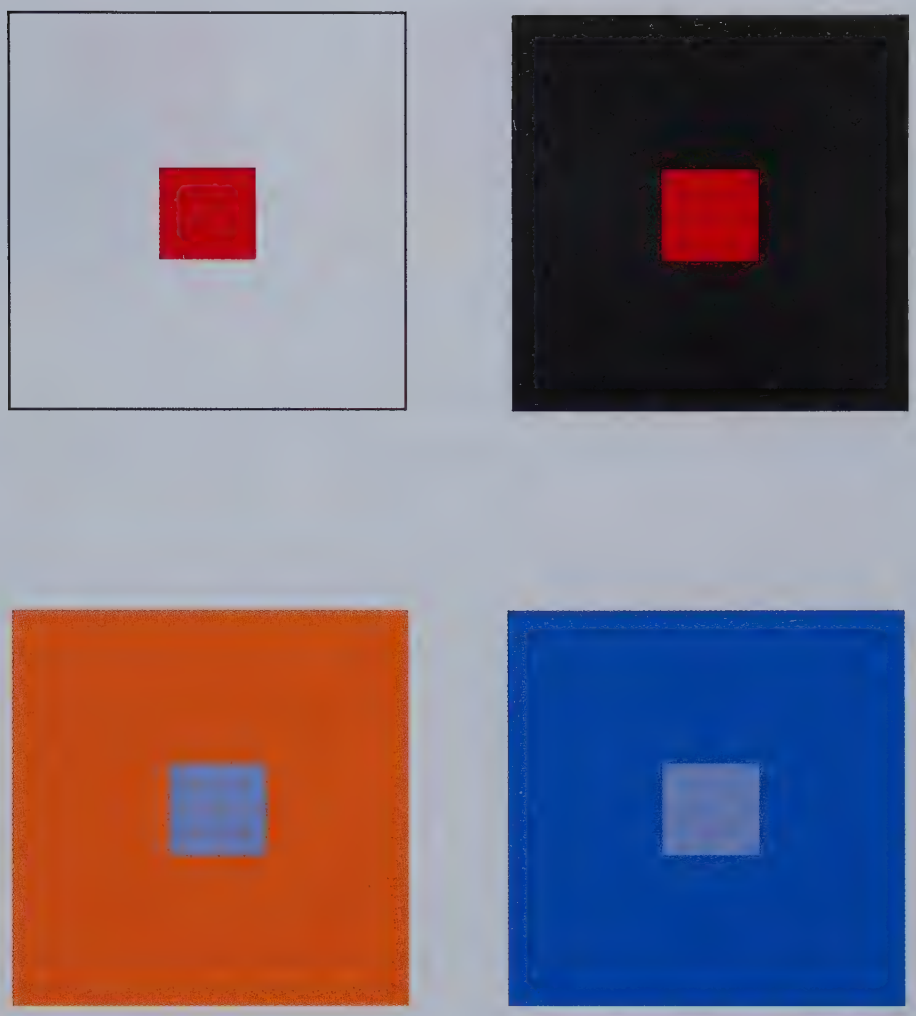


Figure 1–21 Color displays varied appearances depending on its surroundings. Notice the different look of the blue and red in each color environment. This is called relative color or color interaction.

The color discoveries of Isaac Newton and Johann Goethe are still pertinent today. The two theories, that of optics and light (additive) and that of pigments and surface color (subtractive), coexist and interrelate in color study. Both theories are conceptually correct and can be applied to either color media or color perception. The additive and subtractive systems of color are interdependent systems that determine how light and pigment mixtures are made and perceived.

Activities

1. Color and Light Experiments

Objective: The student will gain an understanding of the nature of additive color through hands-on experiments.

- Use a prism or a crystal in a window to refract light into the spectral hues.
- Experiment with colored lights; use a red-, a green-, and a blue-colored bulb to understand both additive (light) and subtractive (surface) color systems in a darkened room. For example: Shine a red light on a green surface, a green light on a red surface, a blue light on a green surface. Overlap two or all three and shine onto a white surface. What colors result from each experiment?

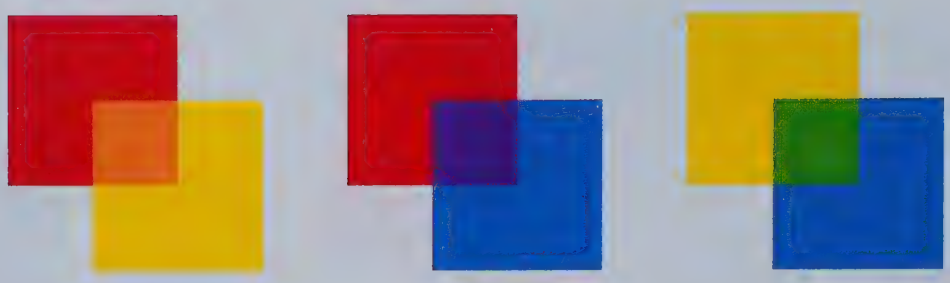


Figure 1–22 Traditional pigment primaries, RYB, mix to form secondary hues.

2. Subtractive Color Study

Objective: For the student to understand the subtractive process by using physical paint mixtures.

- Use process colors (cyan, magenta, and yellow) in acrylic or gouache paints.
- Create secondary colors by mixing CMY primaries [1.22] magenta + yellow, yellow + cyan, and cyan + magenta. Then mix traditional primaries, red + blue, blue + yellow, and yellow + red to make secondary hues. Compare the results between the secondary hues made with the process primary mixtures and the traditional primary mixtures. How do they differ?
- Now mix all three primaries, CMY or RYB, to make a neutral that is close to black or gray.
- Form them into a chart as shown. [1.17]

3. Additive Color on Computer

Objective: For the student to see how additive colors intermix. Also serves as an introduction to computer color mixing.

- On any computer graphic program, go to the RGB color mode.
- Using the RGB sliders, slide the red bar to 100% and green and blue to 0%. What color results?
- Slide all bars to 100%. What color results?
- Slide all bars to an equal percentage. What color results?
- Slide R and G to 100%. What color appears?
- Slide B and G to 100%. What color appears?
- Slide R and B to 100%. What color appears?
- Experiment with other mixtures and try to explain all mixtures according to the information in Chapter 1.

Glossary

Additive system The system of color that uses light. When all the light primaries are combined, the result is white light.

Color A color is specifically a wavelength of light received by our eye that causes a color sensation to be produced in our brain. The word color also means any color derived from any hue; for example, violet is a hue and light violet is a color. A color is not necessarily chromatically pure and a hue is.

Color constancy refers to our ability to recognize a color, aside from its lighting conditions giving a color a stable, fixed appearance.

Color physics The science of color, particularly the science of light and color perception. Color is defined as a visual sensation caused by the components of light either transmitted or reflected to the receptors in our eye.

Cone cells Cone cells are at the heart of our color perception; they selectively respond to specific colors. There are three types of cones: L red (long wavelength) cones, M green (medium wavelength)

cones, and S blue (short wavelength) cones.

Electromagnetic spectrum Energy waves produced by the oscillation of an electrical charge. Electromagnetic waves do not need any material for transmission; that is, they can be transmitted in a vacuum. Light is part of this spectrum.

Local color is the general color of an object under normal lighting (daylight or white light) conditions, the identifying color of the object.

Medial primary colors Red, green, blue, and yellow—a combined group of both the subtractive and additive primaries also called the psychological primaries.

Primary colors Hues that are not obtainable by any other color mixtures.

Process colors The four primary colors used for commercial printing and color photography: cyan, magenta and yellow, also abbreviated as CMY. Cyan, magenta, and yellow are close to the traditional subtractive primary hues of red, yellow, and blue.

RGB Red, green, and blue are the additive primaries of light. RGB also is a color mode used by both the computer monitor and scanner. RYB Red, yellow and blue are the subtractive primaries of pigments and dyes.

Rod cells Rods are cells that help us perceive light/dark (value) differences and lighting strength, particularly in dim lighting situations.

Secondary hues The halfway points between the primary hues; for example, a mixture of red with blue will yield violet (red + blue = violet). Violet is a secondary hue.

Subtractive system In our perception of surface color, some light waves are subtracted, resulting in a reduction of the amount of light reflected to our eye. The subtractive color system is also in use with physical colors such as pigments and dyes, which lose intensity as they are mixed.

Tertiary hues Those hues produced by the mixtures of a primary and a secondary: RO, RV, YO, YG, BG, BV.

Trichromatic theory proved that all colors were generated from the three spectral hues of red, green, and blue.

Visible light spectrum A small part of the electromagnetic spectrum that we can actually see.

Wavelengths of light Each hue in the visible spectrum has a corresponding wavelength measured in nanometers, which are only one billionth of a meter. Hue differences are tiny measurement differences between the crests of each wavelength. Red has the longest wavelength and violet the shortest.

Chapter 2

The Color Circle and Color Systems
An Exploration

LEARNING OBJECTIVES

- An overview of the color circle and its importance, history, and function.
- The relationship of hues and colors; primary, secondary, and tertiary hues; the color circle as a source for color relationships; analogous and complementary; color chords; and color harmony.
- The student will gain understanding of the significance of hues, their placement on the circle, and the relationship of hue and value.

INTRODUCTION

Throughout history, philosophers, scientists, and artists have studied color. Color theorists have endeavored to illuminate the phenomena of color by constructing color circles and organizational systems. Over time, color study has reached in many directions, incorporating perceptual, scientific, physical, and expressive concerns. The common thread of color theory research has involved the effort to organize, systematize, and associate our human experiences with color. *Color systems* are formulated to organize the vast number and extensive variety of colors that we perceive every day.

Why is a color circle necessary for color study? First, a *color circle* sorts the spectral hues into chromatic (color) order. Second, the circle enables us to perceive and establish color relationships between the hues. The circular configuration clarifies the relationships between hues more readily than the spectral color "band." Lastly, the color circle reinforces the notion of each hue as a separate entity of color.

COLOR CIRCLES AND SYSTEMS—A BRIEF HISTORY

Color helps human beings orient themselves to the world. Early in history, color was recognized as a concept separate from and independent of objects. The earliest concept of color was that of white and black: light and darkness. The first *chromatic* concept to be identified was red. Primitive man responded to its powerful associations with blood, fire, and the sun. The remainder of the hues were identified in this order: yellow, green, blue, orange, and brown.

Early color study was an aspect of philosophy. To philosophers, color represented one of man's ways of interacting with the world. The first documented color theorist was Pythagoras, the Greek mathematician, in approximately 500 B.C. He surmised that color existed on the surface of objects and was activated by a hot emission from our eyes. Empedocles, another Greek, concluded in 440 B.C. that energy flowed from both our eyes and the object itself to produce a color sensation. He associated colors with the four elements: fire with white, air with yellow, water with black, and earth with red. The ancient Greeks accepted the four basic elemental colors of white, black, yellow, and red as the primaries.

The Greek philosopher Aristotle (384–322 B.C.) formulated a color theory that was considered authoritative from his time through to the Middle Ages. Aristotle's theory proposed that all colors were actually imperceptible mixtures of black and white; the interaction of white as light and black as darkness. His theories were based on the

Figure 2–1 Aristotle believed that all colors were the result of mixtures between white and black, or light and darkness. Photo credits: Thebext/Dreamstime; FXQuadro/Shutterstock; Lars Christensen/Shutterstock; Igor Kovalchuk/Shutterstock.

observation of color in the sky throughout the course of a day, yellow at noon, changing to orange, then red, green, and finally dark blue. Aristotle envisioned the hues in a linear sequence; his seven basic hues, yellow, red, violet, green, and blue, were placed between white and black. [2.1] Aristotle noted the gap between perceptual and physical color because the artist of Antiquity did not have the pigments to reproduce the hues of a rainbow. This Aristotelian notion became outdated with the development of a wider hue range of pigments and dyes. Another Greek, Theophratus (372–287 B.C.), concurred with Aristotle's theories and, in addition, conceptualized colors as a result of varied light sources.

Color research resumed in the Renaissance. Leone Battista Alberti (1404–1472), an Italian architect and painter, stated in his book *On Painting* that color perception was dependent on light. He also associated colors with the four elements: red–fire, blue–air, green–water, and yellow–earth, which was later amended to gray for earth. [2.2]

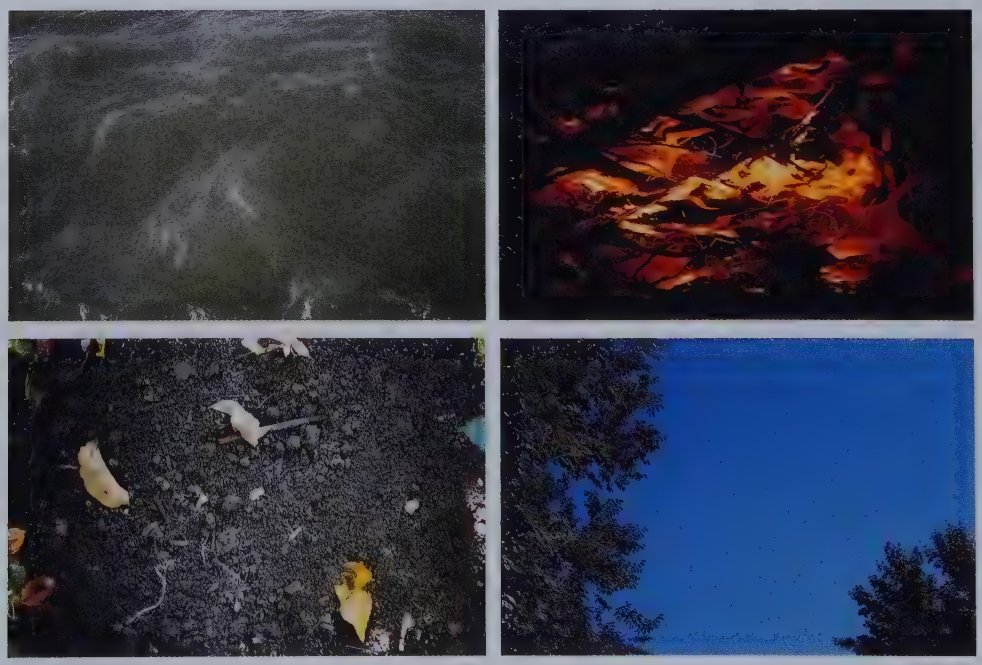


Figure 2–2 Comparisons have often been made between the hues and the four traditional elements. Alberti connected the elements with these hues, clockwise from top right: fire—red, air—blue, earth—yellow, and water—green. Photos courtesy of Becky Koenig.

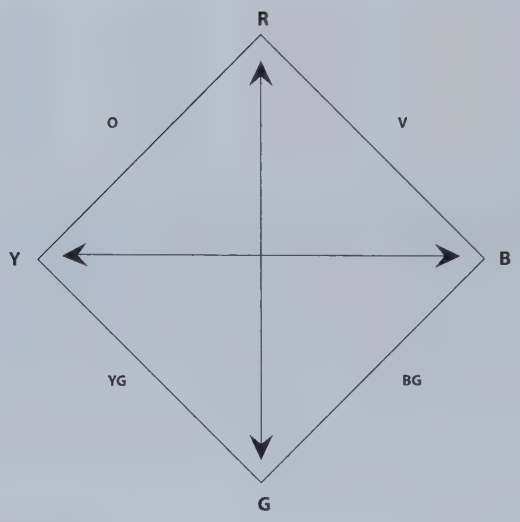


Figure 2–3 Alberti's color chart, in which he identified the essential hues of red, blue, green, and yellow, independent of black and white.

Alberti rejected Aristotle's theory that each hue was a mixture between black and white. He established the chromatic hues of red, yellow, green, and blue as hue entities that are independent from the achromatic neutrals of black, white, and gray. Alberti's color chart laid out the hues in a square formation to indicate their interrelationships. [2.3]

During the High Renaissance, the Italian painter and inventor Leonardo da Vinci (1475–1564) also sought to identify the principal colors that were the building blocks for all other colors. In his *Treatise on Painting*, published in 1651, da Vinci concluded that the principal colors were—listed in order of their importance—white (light), yellow (earth), green (water), blue (air), red (fire), and black (darkness). In the history of color research, color is often connected to elements from our experience of the world. Yellow, green, blue, and red are referred to today as the medial primaries. [2.11]

At this point in time, there was a shift in the study and theory of color that steered it away from the province of art and philosophy and moved it toward scientific research. The English philosopher Francis Bacon (1561–1626) introduced the inductive method in science, which inspired scientists to prove theories by experimentation and data rather than by theoretical pronouncements. Using scientific data to generate theories influenced all scientific research, including color theory.

Studies of light reflection and refraction were contemporaneous with the development of lenses for microscopes and telescopes. Rene Descartes (1596–1650), a French philosopher and mathematician, determined that color was dependent on light, which was comprised of particles. He envisioned the speed and movements of these light particles to be the cause of specific color sensations. He also came closer to an explanation of the formation of rainbows.

A Belgian Jesuit named Franciscus Aguilonius (1567–1617) created what is possibly the oldest known color system of subtractive primaries, naming the colors red, yellow, and blue. His system was presented in a linear formation similar to Aristotle's color sequence. Aguilonius also coined the term *median* or *medial primaries*.

In a text discovered in 1969, a Finnish astronomer and priest named Aron Sigfrid Forsius appears to be the creator of the first color circle. Forsius's volume on physics, dated 1611, contained the first color wheel, drawn in a sphere. It included red, blue, green, and yellow as the main hues, interacting with black, white, and gray.

Prior research on the connection between color and light laid the groundwork for the discoveries of Isaac Newton (1642–1727), as discussed in Chapter 1. In addition to his discovery of the color components of light through refraction, Newton definitively identified seven spectral hues, the number chosen by his desire to correlate the hues with the musical scale. The musical scale was often seen as a parallel entity to the color spectrum, part of an ongoing historical inclination to connect the senses of sight and hearing.

Figure 2–4 Newton identified the seven distinct hues from the light spectrum to correspond to the notes of a musical scale.

By the refraction of light, Newton identified the color components of white light as red, orange, yellow, green, blue, indigo, and violet. [2.4] Newton surmised that all other colors are compounds of these spectral hues. The concept that the spectral hues can also create black and white is diametrically opposed to the color theories of Aristotle. Newton's other major contribution to color theory was his formulation of the first widely known color circle. Since Forsius's color circle was not discovered until much later, Newton has been commonly credited with the origin of the color circle format. By adding one hue (purple or red-violet) to the spectral band, he attached the spectral band to itself in a circle. [1.3] Newton's circle portrays the scale of each hue in proportion to its width in the spectral band. The center of Newton's color circle is white, which is meant to indicate the additive intermixture of all the colors of light.

In Newton's time, it was disputed whether light was comprised of particles or waves. Newton supported both hypotheses in his book, *Optics*, referring to the theoretical particles as *corpuscles*.

Artists involved in the color reproduction processes of printing and engraving made other major color discoveries. A French artist and printer, Jacques Christophe le Blon (1667–1742), discovered that careful mixing of three hues—red, yellow, and blue, along with black—could create a large variety of colors. Today, he is considered to be an early developer of the four-color printing process used for commercially printed material. Le Blon's discoveries pointed the way to the first clear indication of the subtractive primary colors.

Moses Harris, an English engraver (1731–1785), took the discovery of the pigment/subtractive primaries one step further in his development of a color circle. In his book, *The Natural System of Colors* (1766), he presented a detailed color circle founded on the subtractive primaries of red, yellow, and blue, which he placed in the central band of the circle. [2.5] He emphasized red, yellow, and blue as the greatest opposites of all the colors—therefore placing them at the greatest distance apart from each other on the color circle. Harris's color circle incorporates tints of each hue around the outside of the circle, gradating toward the pure hues, and shades of each hue in progressive steps toward the center of the circle. His color circle identifies three primaries, which he called *prismatics* or *primitives*, three secondaries, called *mediate* or *compound* colors, and twelve tertiary hues.

Johann Wolfgang von Goethe (1749–1832), the German poet, was instrumental in the development of a subtractive color system and circle. In 1810, he published *The Theory of Colors*, a book that focused on visual phenomena such as colored shadows. He sought to bring order to the confusion of color. Goethe devised a color circle that was based on the laws of subtraction. Goethe's theories filled the gap between art and science that began with the theories of Newton. [2.6] His color concepts were meant to be in direct opposition to Newton's. In the artists' perspective at the time, Newton's theories of light and color seemed to be unusable to artists engaged with pigment manipulation. Thus, as stated in Chapter 1, there was a seeming disparity between additive light (color sensation) and subtractive surfaces (physical pigmented surfaces).

Goethe brought a subjective slant to his theories of color. He felt that blue and yellow were the hues that held the strongest contrast to each other. His obvious preference for warm hues is expressed by his description of them as "warm, lively, and exciting."

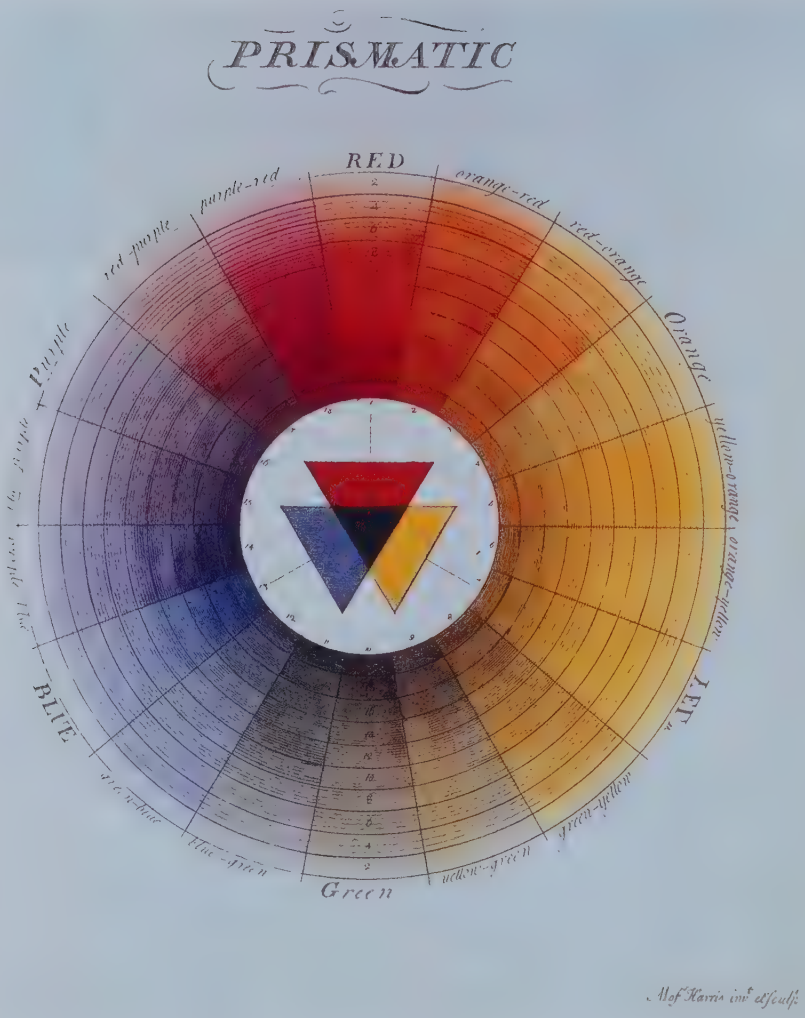


Figure 2–5 Moses Harris's wheel is based on the subtractive primaries and shows each hue tinted with white and shaded with black. From the Natural System of Colors, Collection Royal Academy of Arts, London.

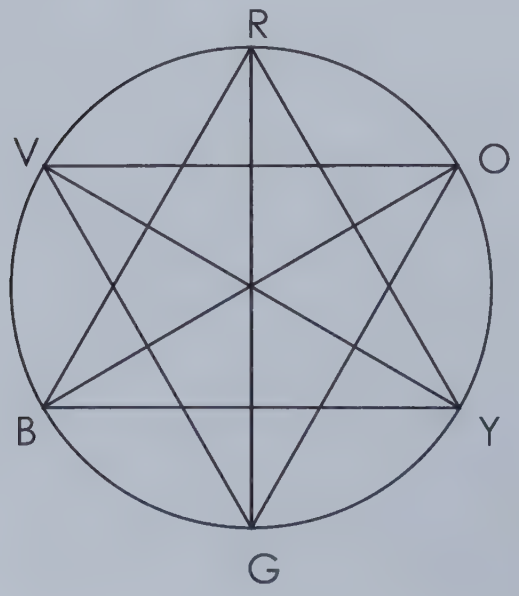


Figure 2–6 Goethe's color circle had three subtractive primaries and three secondary hues.

Cool hues, in contrast, he considered "weak, unsettled, and yearning." Goethe was one of the few color theorists who gave attention to the use of color, materials, and methods in painting. In Goethe's theories, color was created by the interaction of light and shadow, an idea that he supported by experimentation. His color circle and triangle [1.14] clearly indicate the three primaries and three secondary hues of subtractive color.

Thomas Young (1773–1829), an English scientist, established the wave theory of light to refute Newton's prior particle theory, based on his experiments with water and interference colors (colors that reflect off of soap bubbles or oil/water mixtures).

Philip Otto Runge (1777–1810), a German painter, introduced the first spherical color system in 1810. This color sphere was the first system to take into account all three attributes of color: hue, value, and saturation. His theories were closely linked to a previous color sphere formulated by Aron Sigfrid Forsius, in 1611. The three subtractive primaries, red, yellow, and blue, and three secondary hues were included on the Runge sphere. [3.18]

Ogden Rood (1831–1902), a physicist with an interest in color, formulated a color circle based on his discoveries of precise complementary or opposing hues. Rood investigated the concept of optical mixtures. He experimented with various complementary hue combinations with spinning tops to discover exact hue opposites. Each top had a pattern of complementary color pairs that were spun to determine the color "mixtures" that result. Rood determined that the color combinations on the tops that visually mixed into the most neutral grays were precise hue opposites. His color circle has both hue and pigment names to assist artists in finding the exact complement of each hue. Rood's theories were presented in a book titled *Modern Chromatics*, written in 1879.

Herbert E. Ives (1882–1953), a U.S. physicist, developed the hues that are now used as primary printing process colors CMY, namely cyan (syan), magenta (anchlor), and yellow (zanth). Ives's goal was to identify the three hues that, when mixed, would produce the truest secondary and tertiary hues. Ives's color circle indicates the primaries as cyan, magenta, and yellow; the secondaries as green, orange, and violet; and the tertiaries as purple, blue, blue-green, yellow-green, yellow-orange, and red. His circle was an early version of what is now known as process color circle.

Albert Einstein (1879 –1955), the famous German-born physicist, wrote a paper in 1905 in which he theorized that the older particulate theories of light might be viable, as certain experiments did not align with the traditional wave theory of light. Einstein proposed the idea that there were small indivisible units or particles of light energy that he termed *quanta*, which are now known as photons. These quanta/photons travel in a wavelength configuration, incorporating the many prior theories of light and wavelengths. Today, a *photon* is known as a primary unit of electromagnetic energy.

Albert Munsell (1858–1918) was a highly influential U.S. color theorist whose color theories and systems are still widely in use. Munsell's major contributions to color study include a careful color notation system that became standard in the United States, Great Britain, Germany, and Japan. He developed a color circle with ten hues—five primary or "principal" hues: red, yellow, blue, green, and purple. He called his secondary hues "intermediate" hues. Munsell also developed a more extensive color circle in a roughly cylindrical format that is comprised of 100 separate colors. Munsell emphasized the establishment of an objective color standard. His color system evolved into the development of a color "tree" that addressed all the variables of color. [3.14, 3.16]

Ewald Hering (1834–1918), a German physiologist and psychologist, was interested principally in the perception of color. He established the psychological or *medial primary hues* (red, yellow, green, and blue) as the primary colors of perception. [2.7] His color circle presented the four primary hues in equal proportion, opposing each other. His theory was based on the absolute uniqueness of each of the four medial primaries. Colors that are mutually exclusive were identified by Hering as color opponents, and his color theory is known as the color opponent theory. For instance, we cannot discern any blue in red but we can see red in orange. Hering's color circle was also the basis for the Natural Color System, known as NCS.

Figure 2–7 Hering's color circle indicated opposing hue pairs, which he felt determined perceptual color.

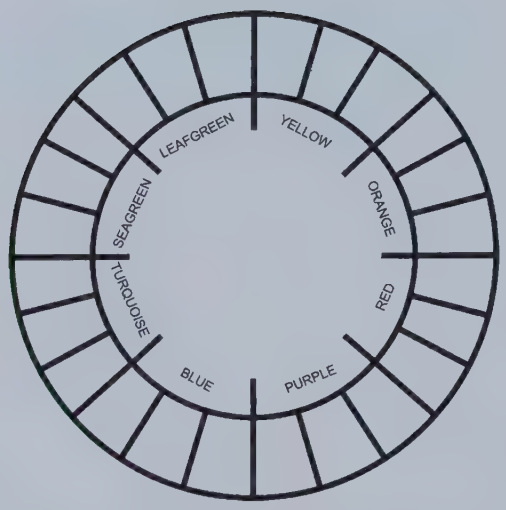


Figure 2–8 The Oswald color circle has eight main hues and it is weighted toward the cool colors.

The German chemist Wilhelm Ostwald (1853–1932) won the Nobel Prize for Chemistry in 1909. He founded his color system on the theories of Ewald Hering. Hering's theory presented the concept that three opposing pair combinations, the red-green and yellow-blue pairs from his color circle as well as black and white, result in all the visible colors. Ostwald adopted this concept and expanded upon it. He developed a highly technical approach to pigmented color. The Ostwald color circle is more heavily weighted toward the cool section of blues and green than in the warm area of reds and yellows. [2.8] Ostwald also compiled a color system that was comprehensive for its time in its organization of the saturation variety of each hue.

In the more recent history of color study, the focus has been on a scientific understanding of the physics of light and color perception and on the international standardization of colors themselves. As mentioned, the Munsell system is considered standard in some countries. The Commission International D'Eclairage or CIE introduced a standard color table in 1931. The objective of this commission was to create a Color Standard Table based on the perceptual additive primaries of red, green, and blue. Precise color matching was achieved by using a colorimeter, which measured hue, luminance (light intensity), and saturation (purity). These three components determine the overall "chromacity" of a color. [2.9] CIE employs a mathematical formula to form color areas, providing an objective international color model. A more recent incarnation of the CIE system (1976) is called CIE LAB color, a more specific color guide, designed for color standards in industry.

Frans Gerritsen is a contemporary color theorist with an interest in color perception and the history of color theory. In his book, *Evolution in Color* (1982), Gerritsen lays out a chronology of historical color systems and then follows this with a description of his own color system. Gerritson classifies all of the principal color systems into four major categories based on their methods of organization. The first of these categories of color theory is *color ordering* between light and darkness, as in the theory of Aristotle. An *opponent or unique color system* is the second type identified by Gerritsen: color systems focused on identification of primary hues and their color opposites, as in Hering's color wheel. The third category of color theory involves the *physical mixing characteristics of colors*, as in a painter's color wheel. The fourth category includes color systems with *color perception* as the basis of their color organization, such as the theories of James Clerk Maxwell, CIE color, and Gerritsen's own color theory. Gerritsen's color theory contends that human color perception, namely RGB additive color, is the ultimate guide for all color theoretical systems.

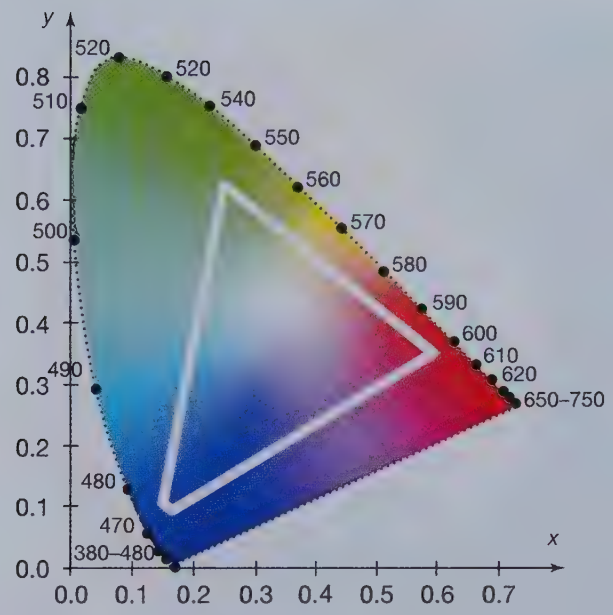


Figure 2–9 The CIE color chart is based on visual the perception of color.

The totality of this historical research in scientific, perceptual, and artist-oriented color systems makes it difficult to select a single principal color system. No single color circle or system is technically suitable for all the aspects, dimensions, and applications of color. The history of color theory is a succession of steps toward our contemporary knowledge of color. The theory of color is ongoing, as the nature of color always leaves us with more to discover.

COLOR CIRCLES—A RATIONALE

Artists and designers work through two principal color modes: additive or subtractive. There are three color circles that are significant for our use today: the *additive color circle*, the *subtractive process color circle*, and the *traditional color circle.* All of these color circles are functional for artists in diverse applications.

Artists and designers work and think primarily in the subtractive color mode. The traditional color circle applies mainly to color subtraction, and artists' materials such as pigments, inks, and dyes. [2.10] For artists who use conventional subtractive media, a traditional twelve-hue color circle is an appropriate reference.

For graphic designers, the subtractive process color circle based on the primaries of CMY is the proper reference for printed color. [1.16]

The additive color circle is significant for color/light processes such as photography, the RGB mode in digital color, and color lighting. [1.9] It should be noted that the additive circle should not be used as a reference for the printing process or traditional art materials.

Because both additive and subtractive color circles are the references for specific art applications, a group of colors called the *medial* or psychological primaries is considered to be the overall core group of primary hues: red, yellow, green, and blue. [2.11] *Medial primaries* are colors with unique, independent hue identities, compiled from the two groups of primaries, additive RGB and subtractive RYB. The concept of four primaries may seem like a departure from the traditional idea of the three primaries on the color circle, but it does not affect the functional systems of RYB or RGB color. For clarity and consistency, much of this book is based on the traditional subtractive color circle. The additive circle or process circle is referred to when it is pertinent for comprehension of printed or digital media.

Figure 2–10 The traditional color circle has three primary hues, RYB; three secondary hues, OGV; and six tertiary hues: RO, RV, YO, YG, BV, and BG.

Figure 2–11 The medial or psychological primaries are the combined primaries of both the additive and the subtractive color systems.

THE TRADITIONAL SUBTRACTIVE COLOR CIRCLE

The *primary hues* are subtractive colors that contain no other hues. We must have primaries to create all the other hues. The traditional color circle has three primary hues: red, yellow, and blue. The primary hues of the traditional color circle match our mental and cultural image of pure red, yellow, and blue. There are also three secondary hues: orange, green, and violet, and six tertiary hues: yellow-orange (YO), yellow-green (YG), blue-green (BG), blue-violet (BV), red-violet (RV), and red-orange (RO) to make a total of twelve hues. [2.10]

The color circle is an organizational system that permits us to distinguish the unique appearance of each hue, each having a separate color identity. Johannes Itten stated that a functional color circle should be simple enough to carry in our memory. The distinct characteristics of each hue on the traditional twelve-hue color circle are crucial to a serviceable color system.

The physical layout of the traditional color circle helps us to formulate numerous relationships between the hues. The color circle is a representation of the gradual change from one hue to another. It also is a means of identifying opposite hues, neighboring hues, or hues spaced apart in relationship with other hues on the color circle.

The traditional color circle clearly represents how the secondary and tertiary hues are produced. The primaries are spaced equidistantly from each other on the circle, with yellow at the top. The secondary hues, which are the mixtures of the primaries, are positioned at the halfway points between the primary hues. [2.12] These mixtures are as follows:

yellow + blue = green
red + yellow = orange
red + blue = violet

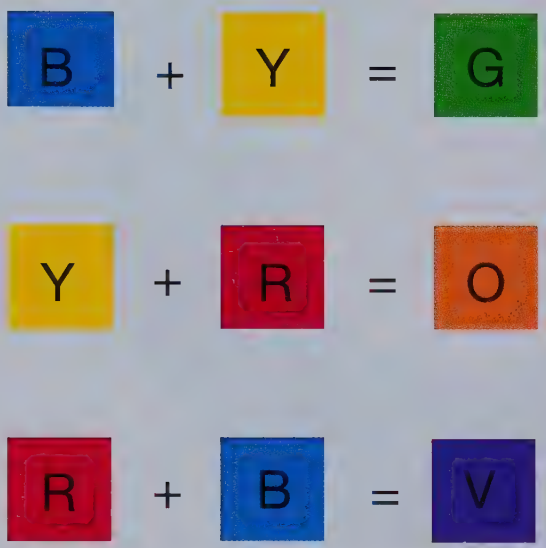


Figure 2–12 Mixtures of the traditional subtractive primary hues form secondary hues, as shown.

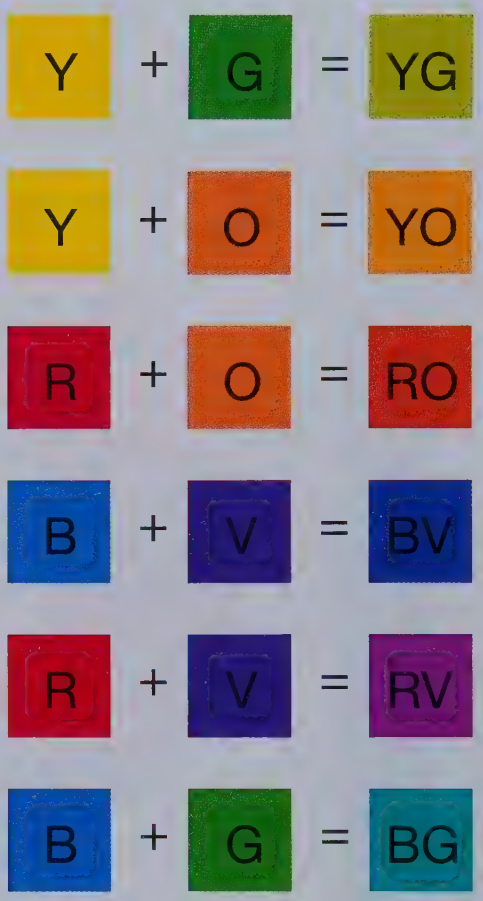


Figure 2–13 How a primary and a secondary hue mix to form each tertiary hue.

The *tertiary hues* are those produced by the mixtures between a primary and a secondary hue. [2.13] The tertiary hues are mixed as follows:

Y + G = YG
Y + O = YO
R + O = RO
R + V = RV
B + V = BV
B + G = BG

Tertiary hues are the visual halfway points between primary and secondary hues. Historically, color circles have had a wide variety of names for tertiary hues. In the traditional color circle, the tertiary names are easy to remember—each name is preceded with the name of the primary hue followed by the secondary hue in each mixture, such as blue-green. Often, the traditional subtractive circle is presented with a gray or black circle in the center to signify the intermixture of all the hues, which blend into a neutral color due to subtraction.

HUES—COMPONENTS OF A COLOR CIRCLE

The word *hue* is defined as either a specific wavelength from the spectrum or a color, in its pure state, from the color circle. The word *color* means a color derived from any hue; for example, violet is a hue and light violet is a color. Unlike a hue, a color is not necessarily chromatically pure and can be nonspectral, meaning it is not directly from

the color spectrum. Each hue has its own identity, characteristics that describe its visual impact. Both primary and secondary hues have qualities that vary in lightness, density, warmth, or coolness, as well as associations with reality. A brief overview of the primary and secondary hues is detailed in Table 2.1.

ACHROMATICS AND THE COLOR CIRCLE

The traditional color circle contains no black, white, or gray. These neutral colors are considered to be *achromatic*, meaning that they contain no chroma or hue. White, black, and neutral grays are the visual steps from light to dark. Often white and black are not regarded as "true" colors because white is a representation of light and black represents the absence of light in the additive color system. However, in color study, achromatics are often regarded as neutral "colors" in themselves. Black, white, and grays are not only entities of value (light and dark) but are also hue *effectors* because of their ability to influence or change the value and/or saturation when mixed with a hue. The sequential value progression of mixtures between black and white generates a series of grays called an achromatic scale. Grays are gradual steps that connect black with white or perfect light with perfect darkness.

The achromatic scale has a unique relationship with the color circle. The achromatic scale paired with a color circle reveals an interactive relationship between two essential components of color: hue and value (see Chapter 3). Chromatic hues mixed with achromatic colors are the origin for a large array of color variations. [2.14]

TABLE 2.1

CHART OF PRIMARY AND SECONDARY HUES

Color	Characteristics	Temperature	Descriptive Names	Pigments
Red	Heavy in density, highly saturated, and medium in value. It is stimulating and active. Refers to blood, fire, and the sky at sunset. It seems to "glow within itself" (Kandinsky). A subtractive and an additive primary.	Warm	Scarlet, Crimson, Maroon, Flame, Burgundy	Cadmium Red, Quinacridone Red, Alizarin Crimson, Indian Red
Yellow	The lightest-value hue, high saturation, low in density. Seems to emit its own light. Reflects both red and green wavelengths. A subtractive primary. Refers to the sun and activity.	Warm	Lemon, Brass, Gold, Sand, Amber	Cadmium Yellow, Hansa Yellow, Zinc Yellow, Naples Yellow, Gamboge
Blue	Medium in value and density, saturation, and weight. Quiet and restful. Refers to distance, the sky, and water. An additive and subtractive primary hue.	Cool	Sky blue, Azure, Navy blue, Indigo	Ultramarine Blue, Cobalt Blue, Cerulean Blue, Phthalo Blue, Prussian Blue
Green	Medium density, saturation, and value. Quiet and soothing. Refers to plants, trees, water, and landscape. An additive primary and a subtractive secondary hue.	Cool	Sea green, Emerald, Leaf green, Jade, Apple green, Sap green, Olive	Permanent Green, Green Earth, Viridian Green, Sap Green, Cadmium Green
Orange	Has light from yellow and glows like red. Light in value and low in density; high in saturation. Associated with warmth and assertiveness. A secondary hue.	Warm	Pumpkin, Peach, Sunset, Rust	Cadmium Orange, Cadmium Yellow Deep, Azo Yellow Orange
Violet	Darkest hue, heavy in density and weight, and medium in saturation. Dignified and rich; suggests darkness, night, and water. A secondary hue.	Cool	Mauve, Purple, Plum, Lavender	Dioxazine Purple, Manganese Violet, Cobalt Violet, Ultramarine Violet

Figure 2–14 The neutrals or achromatic colors can be seen as hue effectors. Color variations are made from combinations of neutrals and hues.

HUE CONTRAST

The strongest type of color contrast is value contrast, pure white to pure black. However, spectral hues also have a characteristic ability to contrast. In chromatic hues, the strongest contrast is between the subtractive primaries, red, yellow, and blue. When pure primary hues are juxtaposed, a potent contrast is evident because each hue is unique and contains neither of the two other hues. Secondary hues (green, orange, and violet) also strongly visually contrast with each other. However, secondary contrast is softened by the primary hue components that they have in common, such as red in both violet and orange, yellow in both orange and green, and blue in both green and violet. [2.15]

Some informal hue contrasts are achieved by a combination of opposing hues or light/dark combinations. Pure undiluted hues (high-saturation hues) form the most potent hue contrast. When black and white are included in a color contrast grouping, it intensifies the disparity. Hues widely separated on the color circle generate a stronger hue contrast than neighboring hues. [2.10] For example, a yellow and blue-green combination has a stronger hue contrast than the contrast of yellow and orange. The maximum contrast (besides the contrast between primary colors) is of hues located directly across from each other on the color circle. These are called *complementary* hues. [2.19]

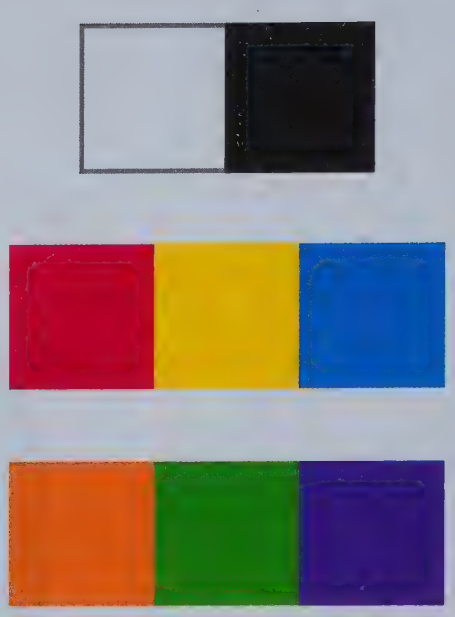


Figure 2–15 Hue Contrast. The highest color contrast is between black and white. The strongest chromatic contrast is between the primary hues. The secondary colors have somewhat less contrast. The greater the separation of hues on the color circle, the stronger the contrast between hues.

HUE RELATIONSHIPS ON THE COLOR CIRCLE

Hue Values

As we explore the color circle, we can distinguish several types of hue relationships. The relative light/dark value of the hues on the circle is evident when the color circle itself is seen as an informal value chart of the hues. As we scan the color circle from the top to the bottom, the hues gradually become darker. Yellow, at the top of the circle, is the hue with the lightest value. Violet, placed at the base of the color circle, is unquestionably the hue with the darkest value. Red and green are located at approximately the same middle level as medium value-hues.

Color Temperature

The color circle also charts relative *color temperature* of hues. We instinctively associate the notion of temperature with color, connecting two sensory experiences. Strong visual associations from our culture and environment cause us to feel that red is warm in temperature because of its reference to blood, fire, and the sun. A similar correlation causes us to feel that blue is cold in temperature because it refers to water, ice, and the sky. Warm hues seem to emit light and heat, and cold hues suggest coolness, distance, and shadow. The color theorist Charles Hayter, an English architect and painter (1761–1835), in his book, *Introduction to Perspective*, was perhaps the first color theorist to base his color circle, which he called *A Painter's Compass*, on color temperature.

The placement of cool and warm hues on the color circle roughly divides the wheel into two halves, a cool side and a warm side. [2.16] The segment of the color circle from yellow through red is definitively warm, whereas the section of green through violet is definitely cool. Tertiary hues of yellow-green and red-violet are borderline hues. Color theorists are divided on whether these hues are warm or cool, thus they can be regarded as flexible in temperature. Warm colors are thought to be more powerful, dominant hues than cool hues. Brilliant warm hues or colors can make an object appear to be larger. Areas of warm hues such as red and yellow also form distinct boundaries, differentiating or segregating from each other more effectively than cool hues.

The concept of cool and warm hues not only refers to temperature but also can create a physical temperature sensation in the viewer. This effect is noticeably strong in

Figure 2–16 Cool and warm sections of the color wheel. Approximately half of the color wheel is considered warm and half is cool; RV and YG are the borderline hues.

interior design, when colors visually surround the viewer. A pure red interior is stimulating and creates a warming effect on the occupant of the room. A blue in an interior has a restful, yet cooling sensation on the occupant of the room. There is no definitive data on which hue is the coldest and which is the hottest, as color temperature is a subjective experience. According to the Swiss artist and color theorist Johannes Itten (1888–1967) in his book, *The Elements of Color*, the warmest hue is red-orange and the coolest is blue-green. Most theorists concur, identifying a red as the warmest hue and some type of blue as coolest hue, respectively.

Hues are identified as cool or warm by their locations on either side of the color circle, but any primary or secondary hue can also possess a cool or warm *aspect.* For example, red, a warm color, can be made even warmer when yellow is added to it to make red-orange. Red is cooler with blue added, which creates a red-violet. [2.17] Cool and warm aspects of each secondary hue may also be perceived, such as a warm violet

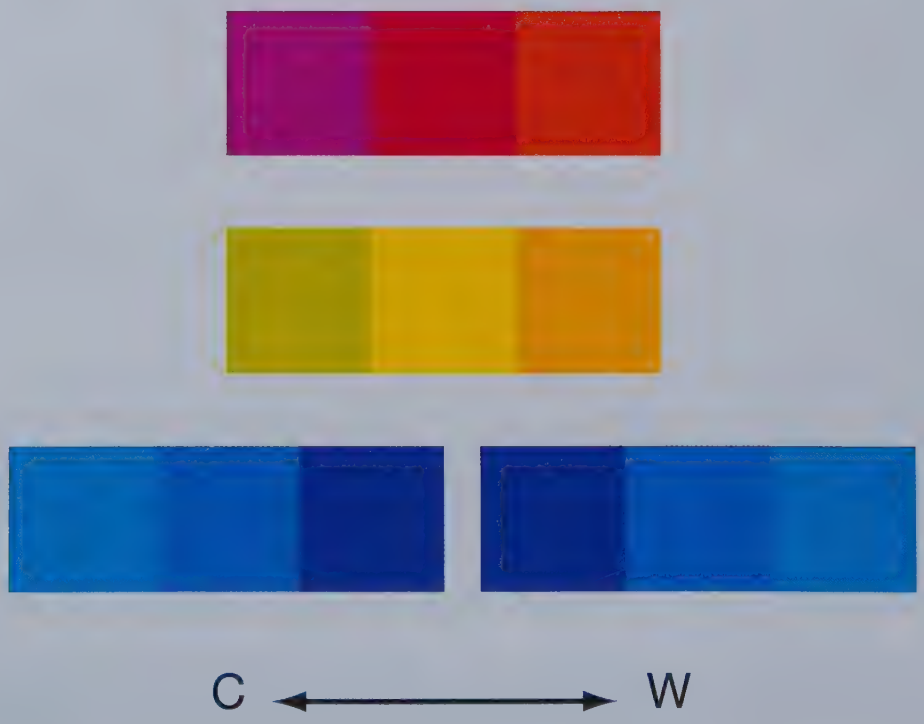


Figure 2–17 Each primary can have either a cool or warm aspect, as shown here. The cool/warm aspect of blue can be seen two ways, with either BG or BV regarded as a cool blue.

that is a red-violet. Color theorists do not concur on which type of blue is cool and which blue is warm. A cool blue can be one that leans toward blue-green, but often a blue-violet based blue is thought of as cool. For painters, however, a cool blue always bends toward blue-violet, such as ultramarine blue, whereas a warm blue is a blue-green such as cerulean blue.

The concept of cool and warm color helps artists or designers to create striking color contrasts and visual effects. The cool and warm colors may be manipulated to bring about an illusion of spatial depth. Cool colors are traditionally thought to recede spatially. Warm colors are customarily viewed as colors that advance spatially. This "rule," though valid, is easily broken. Cool colors may advance if they are sufficiently pure or high in saturation. Warm colors can recede if they are low in saturation or muted. Cool/warm contrasts generally evoke the following visual opposites:

Warm		Cool
light	—	shadow
summer	—	winter
fire	—	water
fall	—	spring
dry	—	wet
close	—	distant

Color Harmony

Color is a wide and rich element of visual art. It is also extremely complex, due the sheer number of color variations. For this reason, color theorists, artists, and designers have always been in pursuit of *color harmony*, which is the formation of a group of colors that visually unify in some manner (see Chapter 9). The layout of the color circle serves as a guide to formulate color harmonies based on the relative placements of hues. The circle provides us with a compass for choosing color families, color opposites, and color chords.

Color Families

A key relationship between the hues on the color circle is the concept of color families, also called neighboring or analogous hues. *Analogous hues* are groups of two or three neighboring hues on the color circle. [2.18] Analogous groups are adjacent to each other on the color circle, for example, the color group of blue, blue-violet, and violet. The B, BV, and V analogous group is bound together by the fact that each hue contains blue in some proportion, visually connecting them. Working with a color family is a simple and harmonious way to organize color.

Color Opposites

The importance of hue opposites, called complementary colors, cannot be overemphasized in color study. Chromatic opposites are two hues located directly across the color circle from each other. They are called *complementary hues*, or complementary *dyads*, since they are always in pairs. [2.19] The complementary opposites from the traditional subtractive color circle are blue–orange, yellow–violet, and red–green. Each one of these pairs has one primary and one secondary color. Complementary pairs are chromatically balanced because each pair contains all three primaries as follows:

Red—Green (yellow + blue)
Blue—Orange (yellow + red)
Yellow—Violet (blue + red)

Note that the subtractive complements vary slightly from the additive color complements of magenta–green, yellow–blue, and cyan–red, described in Chapter 1.

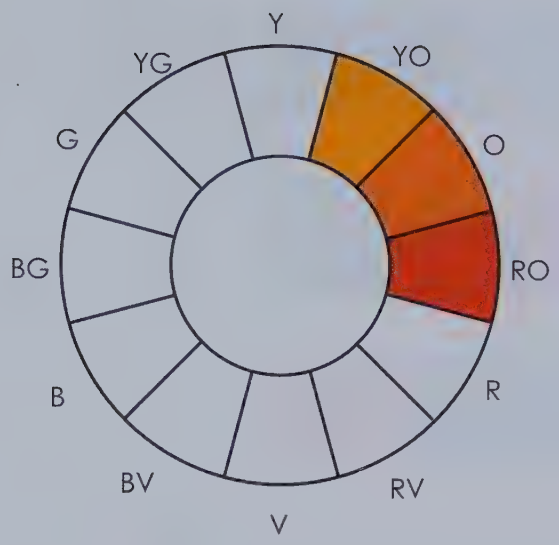


Figure 2–18 Hues that are neighbors on the color circle have an analogous hue relationship.

Figure 2–19 The traditional subtractive complementary pairs are red–green, blue–orange, and yellow–violet.

We also have a physiological relationship with complementary hue contrast. When our eye becomes tired or saturated with one hue, our eye spontaneously produces its visual opposite or complement. This phenomenon is called an *afterimage.* The concept of afterimage is an important part of color interaction. [4.1]

Complementary hues also neutralize each other. In the subtractive color system, the three primaries cancel each other out to create a near neutral when mixed together (as with paint). As each complementary pair has all three primaries in varying proportions, the hues of each pair will neutralize each other, forming achromatic colors such as brown or gray when mixed. A red-to-green scale demonstrates how complementary mixtures create muted versions of the hues toward the ends of the scale and neutralization of the hues in the center of the scale. A complementary or dyad pairing is also regarded as a type of color harmony. [2.20]

Color Chords

Groups of hues that are set apart on the color circle are called *color chords.* Color chords are hue selections from the color circle that create specific color harmonies. A musical chord has three or four notes spaced apart that create a harmonious sound. Color chords parallel this concept as they are formed by hues spaced at intervals on the color circle. Each color chord has a different quality of harmony, just as a musical chord has a different quality of sound. For example: A triadic chord is comprised of hues that are equidistantly spaced on the circle: red, yellow, and blue. A tetrad color chord is made from four hues in a different evenly spaced arrangement: yellow, blue-green, red-orange, and violet. A color chord systematically unites three or four seemingly unrelated hues to produce a color harmony.

Figure 2–20 Complementary hues in the traditional subtractive mode will neutralize each other. Shown here are incremental mixtures of red and green. Courtesy of Becky Koenig.

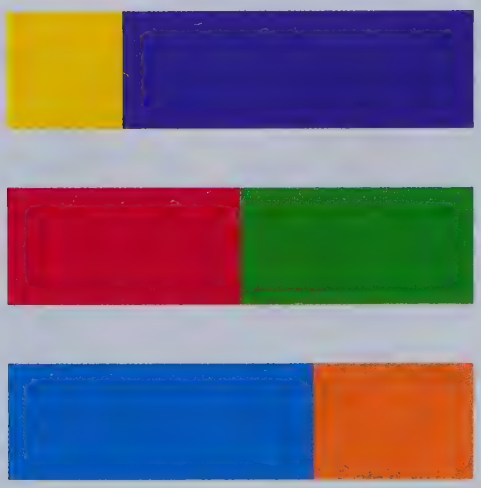


Figure 2–21 In Goethe's numerical value system of color proportion, each hue should occupy a designated area for color balance.

COLOR PROPORTION

Color proportion is another strategy in the quest for color harmony, making use of measured ratios of pure hues to achieve color balance and harmony. Color proportion is based on the varied saturation or color intensity levels of pure hues. These proportional systems are designed to compositionally balance the relative visual weights of pure hues. Johann Wolfgang von Goethe, the author of *The Theory of Colors* (1810), formulated a system of color proportion by creating a simple ratio for the relative physical areas that each pure hue should occupy for color harmony. Goethe reasoned that yellow, a powerful hue that is the lightest and, in his view, the highest-saturation hue, should occupy the least relative space in a composition. According to Goethe's rationale, violet is the darkest but also lowest saturation hue, so it should occupy more physical area than yellow for compositional balance. In Goethe's system, the physical area for each hue is based on a numerical code assigned to each hue, which dictates how much space each hue should occupy relative to other hues. [2.21] The numerical value for each hue is as follows:

Yellow—3 Orange—4 Red—6 Green—6 Blue—8 Violet—9

According to this proportion, harmonious areas of red and green should be equal, each using 50 percent of any given space. Violet and yellow would use 1/4 yellow to 3/4 violet, since the value of violet is three times as much as yellow. [2.22] Yellow's

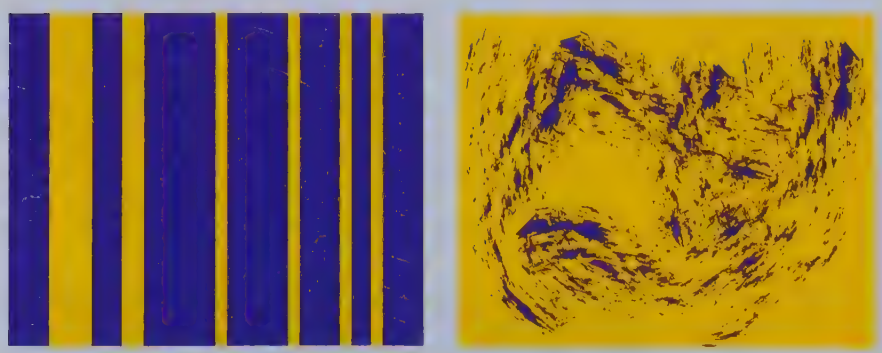


Figure 2–22 On the left, Goethe's proportional system applied to design. On the right, this proportional system can be inverted for a more exciting color effect.

proportion to green would be 1/3 yellow to 2/3 green. Goethe's proportional "rule" should be viewed merely as a guideline. To increase hue contrast, the harmonic area ratios can be ignored or even reversed. To create a more visually exciting proportion, for example, yellow can be allowed to dominate violet.

The exploration of the color circle leads to several conclusions. First, the color circle is an essential tool for the study of color relationships. Second, the color circle provides us with a guide from which to select hues for color harmony. Third, the color circle is the starting point, in conjunction with the achromatic neutral scale, to create the millions of colors that we see.

Activities

1. Color Circles

Objective: For the student to formulate multiple types of color circles in order to understand the distinctions between the traditional color circle, the process color circle, and a subjective color model.

Media: Gouache or acrylic paint on paper, mounted on illustration board.

A. Traditional Color Circle

- Make a traditional color circle using tempera, gouache, or acrylic paint.
- Make sure that you have both primary RYB and secondary color paints, and orange, green, and violet before you start. See notes on materials.
- Paint out swatches of the three primary hues, RYB, from pure colors out of the jar or tube. Paint the three secondary hues OGV. Paint each swatch out on good drawing paper, making them at least 3 inches square.
- Mix the tertiary hues, YO, YG, BG, BV, RV, and RO. When mixing light-value hues such as yellow-green, start with the lighter hue, yellow, and add green into it. Use a magenta-based red when mixing RV. Place each tertiary hue between the primary and secondary swatches to check that it is a visual halfway point between hues.
- Color circle wedges are made by using a compass to make an 8 or 10 inch circle. A protractor divides the circle to make twelve sections by making a line every 30°. Make a template from one section of this circle. Cut twelve painted hue swatches using the template as a guide. Draw another color circle with divisions as a guide for gluing the cut wedges into a complete circle with twelve sections, with the hues correctly placed. [3.29]

B. Process Color Circle

- Make another color circle from the process hues, CMY. Many brands of paint offer a reasonable facsimile of these hues.
- In this color circle, all of the twelve hues are mixed from the three process primary colors. Paint out the process primaries and mix the secondaries as follows: cyan + yellow for green, magenta + yellow for orange, cyan + magenta for violet.
- The six tertiary hues have to be mixed carefully, with attention to relative proportions of each CMY primary in each color mixture. YO, for example, is yellow with just a tiny amount of magenta. BG is cyan with a small amount of yellow and so on. [2.23] Assemble the color circle as indicated in Activity A.

C. Subjective Color Model

- Make a color model based on a personalized concept of the most important hues. The circle can, for example, have more cool colors than warm hues. Use your own versions of pure red, yellow, blue, and green, even if you have to mix the colors. Come up with a format (it doesn't have to be in a circle) based on your own design. [2.24]

Figure 2–23 The subtractive process color circle uses CMY primaries mixed to form the secondary and tertiary hues.

Figure 2–24 An invented subjective color wheel based on personal color preferences.

2. Complement Scale

Objective: The student should understand the sequential neutralization of each hue by complementary mixture.

- Make a scale from each principal primary–secondary complement pair or dyad: blue to orange, yellow to violet, red to green.
- Start with one hue, for example, a swatch of pure red. In steps, add small amounts of green to the red, painting a swatch after each addition. As the green is added, red will become successively more neutral, toward brown or gray. Start again with pure green and gradually add red in stages, painting a swatch each time the color changes.
- Present the entire scale with red at one end and green at another as shown. There should be nine or eleven steps in this scale, each represented by a 1 inch square. The central step in each scale should be the most neutral color. [2.20]

3. Warm/Cool Aspects of Hue

Objective: The student should be able to create from paint or choose from paper warm and cool variations of hues.

- Use each primary color to make warm and cool hue variations.
- For example, paint a swatch of primary red or pick out one from a Color Aid® paper pack.
- Now make a warm red by adding a tiny amount of yellow or a larger amount of orange. If using colored paper, be sure that your warm red has an orangier cast than your primary red.
- Make a cool red. Adding a tiny amount of blue or a larger amount of violet will achieve this. With paper, you will look for a red with a more violet cast.
- Repeat the same process with blue and yellow. This study can be also executed with secondary hues. How can a violet be cooler? Warmer?
- Present each hue adjacent to the main hue in the center and the cool and warm aspects of the hue on either side in 1 inch squares of color as shown. [2.17]

Figure 2–25 Hue Contrast Study. Hue and color choices in juxtaposition emphasize maximal hue contrast.

4. Hue Contrast Study

Objective: To perceive and juxtapose the strongest hue contrasts.

- From colored paper or painted swatches, pick out ten strongly contrasting hues or colors. Black, white, and gray can also be included.
- Place colors in a grid that maximizes the contrast between the hues, as shown. Each grid piece should be 1 by 2 inches, making the overall size 4″ × 5″. [2.25]

5. Color Proportional Study

Objective: To use the balanced proportional system for pure hues as devised by Goethe and then design and use an opposite system.

- Use two or three hues in a simple proportional study. Try to employ correct proportions for each hue according to Goethe's numerical system as described in the text. [2.21]
- For example, if you made a study out of violet and yellow, use three times as much violet as yellow (be sure to measure square inches of each). You can use painted paper or Color Aid® paper. [2.22]
- Cut apart the colors into simple geometric shapes and then make your design using only the "correct" Goethean proportions.
- Next, make a study where you reverse or invert the proportions or come up with your own system of color proportion.

Glossary

Achromatic Achromatic colors are neutrals, meaning that they contain no chroma or hue. An achromatic color scheme uses all achromatic or neutral colors: black and white, and a full value tonal range of grays.

Analogous colors Colors that are adjacent to each other on the color wheel, for example, blue, blue-violet, and violet. An analogous color scheme is based on the idea of a color family, using two or three neighboring hues from the color circle as a starting point.

CIE The Commission International D'Eclairage introduced a standard color table in 1931 based on the additive primaries of red, green, and blue. It uses a mathematical formula to create its color areas, providing an objective perceptual color model. A more recent incarnation of the CIE system (1976) is called CIE L*A*B* color.

Color circle or color wheel Newton is commonly credited with the origin of the color circle or wheel format. By adding purple to the spectral band, Newton attached the spectrum to itself in a circle. The color circle provides a format to understand hue relationships.

Color contrast The manners in which colors may contrast are by value (light/dark), hue, temperature (cool/warm), complementarity, and saturation (muted/brilliant).

Color proportion Johann Goethe conceived of a system of color proportion in which a simple ratio system is used for balancing areas of pure hues in a composition.

Color temperature Refers to our sense of warm or cool colors. For example, red is warm in temperature because it refers to blood, fire, and the sun; blue is cold in temperature because of its reference to water, ice, and the sky. Each primary and secondary hue also has a cool or warm aspect; for example, red is cooled when blue is added, creating red-violet.

Hue Hue means any wavelength from the visible spectrum. A hue is a specific color selection from the spectral color circle in its pure state, sometimes referred to as a spectral hue. Hues may be a primary, secondary, or tertiary color.

Local color The general color of an object under normal lighting conditions.

Medial primaries A color concept that combines the two primary groups RGB (light) and RYB (pigment) to form an overall group of hue primaries, red, yellow, green, and blue.

Photon A *photon* is known as a primary unit of electromagnetic energy, a particle of light.

Primary colors Hues that are not obtainable by any other color mixtures.

Secondary hues The halfway points between the primary hues; for example, a mixture of red with blue will yield violet (red + blue = violet). Violet is a secondary hue.

Tertiary hues Those hues produced by the mixtures of a primary and a secondary: RO, RV, YO, YG, BG, and BV.

Chapter 3

Attributes of Color

LEARNING OBJECTIVES

- The chapter focuses on the attributes of color to replace will reinforce the student's knowledge of the principal characteristics of color: hue, value, and saturation, and how these color attributes can be changed and varied.
- A brief overview of some of the more important color systems invented to provide a visual guide to all the color attributes, collectively. These charting systems and color solids help the student to understand how the attributes of color interact and organize our concept of color.

INTRODUCTION

The complexity of color offers the artist a world of choices. The vast number of colors that can be discerned by the human eye has inspired many color theorists to design systems of color organization. James Clerk Maxwell (1831–1879), the Scottish physicist who made notable contributions to color research, identified three distinct color dimensions or characteristics to represent the complexity of color. These color characteristics are called *color attributes.* A comprehension of the attributes of color—its characteristics and dimensions—offers a strategy that can guide color selection.

The three principal attributes of color are the characteristics of hue, value, and saturation. *Hue* refers to a specific color wavelength from both the spectrum and color circle. *Value* refers to the lightness or darkness of a color. *Saturation* is a property of color that highlights its purity, intensity, or chroma. It is difficult to conceptualize all three color characteristics at once, so each color attribute—hue, value, and saturation—is examined here as a separate entity.

HUE

The term hue refers to a spectral color in its pure state. A *hue* is a single color from the color circle, such as violet. [3.1] A hue is, to some degree, also *defined* by its location on the color circle. Often a hue selection is the first color choice that an artist makes, and it forms the basis for all the other color dimensions. By choosing the hue BG, for instance, it becomes the source hue for a group of color variations on BG—light, dark, muted, or brilliant.

Hue Names

The terms *hue* and *color* have separate and distinct definitions. A *hue* is a particular spectral color from the color circle, while a *color* is any variation on a hue or neutral. Hues are spectral colors and color mixtures are nonspectral colors. Thus, a hue is the basis or source for all color varieties. The neutrals are *achromatic*, containing no hue or color, whereas colors are *chromatic*—meaning that they contain some hue. The name of each spectral hue often references its many color variations. For instance, a red mixed with white (commonly called pink) may be referred to as a tint of red, which clarifies its hue source. Pink is a *descriptive color name*, as opposed to a spectral color name. Descriptive color names are numerous and often fanciful, such as: scarlet for a warm red, teal for blue-green, and chartreuse for yellow-green. [3.2] Descriptive color names are useful to identify large numbers of colors for commercial or consumer product items, such as the colors of makeup or interior wall paint. For color study purposes, it is clearer to reference a color by the hue from which it is derived; for instance, a "hot pink" is really a tint of red-violet.

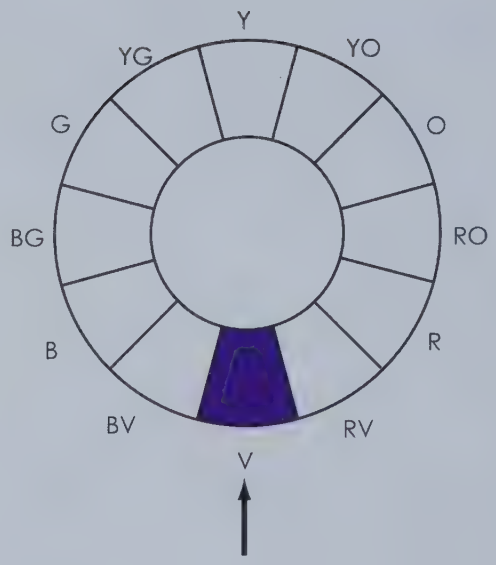


Figure 3–1 A hue is, in part, defined by its location on the color circle.

Pigments, the colored powders that produce paint are often used as color names such as cerulean blue, which can be confusing. Students want to know which pigment is the "true" red, blue, and so forth. Pigment names often point to the chemical or mineral content of the colors. We *do* need to know at least some pigments and their hue equivalents on the color circle. Cadmium Red Light is, for instance, a red orange, Magenta is a red violet, and Napthol Crimson is a spectral red. Familiarity with pigment names is crucial when working with various types of paint (see Table 2.1 on page 28).

Hue Standards

Throughout the history of color theory, there have been numerous attempts to create international systems to standardize hues. Printers' process inks in CYMK hues, cyan, yellow, magenta, and the achromatic black (the letter K is used as a symbol for black), are used internationally, with some variations of color by manufacturer and country. Digital graphic color modes, such as RBG and CIE color, are also standardized. An older standard for hues is the Munsell system of colors, which is a color standard in the United States (the National Bureau of Standards), Great Britain, Japan, and Germany. There is also the Swedish Natural Color System (NCS), which is often regarded as a standard color system.

Hue Identification—Base Hues

In order to effectively manipulate color, we must first sensitize the eye in order to heighten our color perception. Hue perception is reinforced by a practice of *hue identification*, which is a method to distinguish the base hue of a color. The *base hue* of a color is the spectral hue origin of each color—its source hue—from which each color is derived. For example, the base hue or identity of the color lavender is blue-violet because the

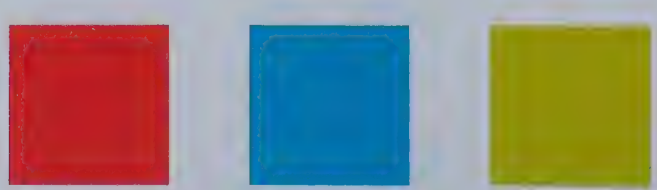


Figure 3–2 Descriptive names for colors include, from left to right, scarlet for RO, teal for BG, and chartreuse for YG.

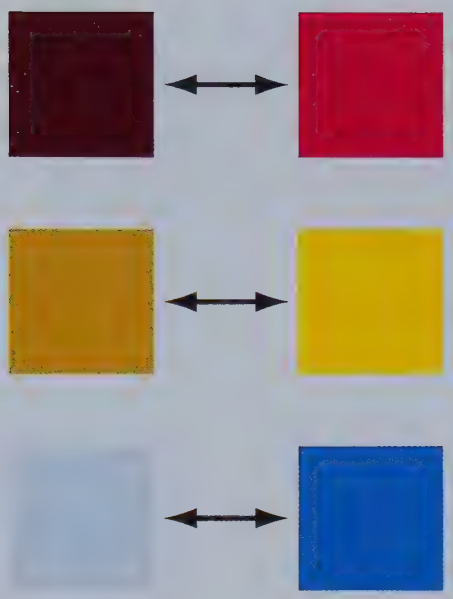


Figure 3–3 Base Hues of Colors. Notice that each color on the left visually relates to a base hue on the right: red, yellow, and blue.

components of lavender are mainly BV + white. We perceive thousands of colors that can be visually traced back to the twelve hues of the traditional color circle. This is the core supposition of the notion of a base hue. [3.3] Neutral colors (achromatics) contain only black and white and thereby have no identifiable spectral hue basis. Even a metallic color such as gold can have a hue relationship to yellow, red, or orange. Earth colors are often based on a hue; for example, burnt sienna can be traced back to a red-orange.

To effectively select colors and invent color harmonies, our eye should be able to discern the base or source hue of almost any chromatic color. A simple hue identification exercise sensitizes our eye for this process. For this exercise, sample colors are first taken from several types of sources: colors from found colored paper, magazine stock, fabric, wall-paint samples, digitally printed color, and/or Color Aid® paper. Each color sample is then visually identified to connect it to a specific primary, secondary, or tertiary hue. To accurately identify hues and aid color perception, colors should be isolated against a neutral background of black or white. Light colors are best identified against white, dark colors against black. [3.4] Each color should be identified by its association with a single hue; the beige shown here, for example, has a base hue of yellow.

Figure 3–4 A questionable color placed against a neutral helps to determine its base hue.

Hue Variation

After the student is proficient in identification of base hues, hue variation studies can be produced. The purpose of a hue variation study is to find or make the largest group of color variables based upon one source hue. Ten color variations on any chosen source hue (such as violet) form a hue identification/variation study that can be made from colored paper. [3.5]

A second hue variation can be either produced digitally or made manually with paint. The purpose of this study is to make a group of varied colors through paint or digital color mixtures that retains the same base hue. For example, a large group of colors can be mixed—light, dark, dull, and bright—that all share the same base hue of green. To make green variations, green paint can be mixed with white in a number of lightening steps, or shaded with black in a number of darkening steps. The green can also be mixed with gray in varying proportions to create more colors. Intermixtures of green with other hues in modest proportions can produce even more colors. Care must be taken that green still remains visually dominant in each mixture; the resulting color should not be too blue-green or yellow-green. The color yield of these mixtures should visually connect to green as the source hue.

We can discover the relative strengths of pigmented color in mixtures through the process of mixing paint. Light hues, such as yellow, are easily altered by the addition of any other hue. Intense or darker hues, such as red or violet, have the power to dominate color mixtures. In hue-to-hue mixtures, hues are more visibly changed by mixtures with hues that are located farther away on the color circle. The concepts that guide pigment mixtures are also evident in digital color mixtures. For example, when blue is added to red, a marked transformation occurs in the original hue of red, pushing the red toward the secondary hue of violet. Neighboring hues on the color circle that are mixed together will not affect source hues as intensely. For example, a red is only slightly affected by a mixture with RO, yet it is strongly influenced in a mixture with green.

The practice of hue identification and variation heightens a student's color perception and strengthens the ability to form many colors, even within the restriction of a single hue.

VALUE

Value is an attribute of color and is also an element of design. *Value* refers to all the perceptible levels of light and dark colors from white to black. In either achromatic or chromatic colors, value is an element of art that is bound to the concept of light. Value levels are most easily perceived as a series of neutral grays. Our eye can discern a surprisingly large number of neutral gray steps between white and black. A standard, workable, neutral value scale, however, is most often a reasonable size, ranging from ten to twelve value steps, including white and black. We also may conceptualize a value

Figure 3–5 A hue identification exercise on the hue of violet. The aim of this exercise is to find or make a wide variety of colors that share in common the same base hue.

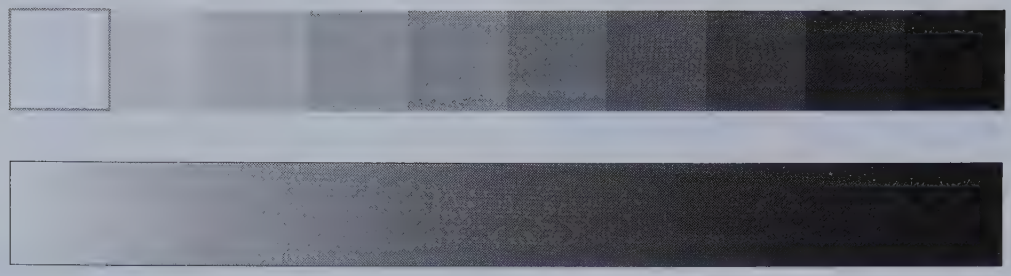


Figure 3–6 A neutral or achromatic scale with ten value steps and in a gradation format, including black and white.

scale from white to black as a continuous band or value *gradient*, a gradual, smooth transition from one value to another. [3.6]

Value Scales: Tints and Shades

The value of a hue may be controlled by adding varied amounts of white or black to a hue. The simplest way to lighten the value of a hue is to add white. The simplest way to darken the value of a hue is to add black. A hue + white is called a *tint.* A hue + black is called a *shade.* [3.7]

When hue is linked with value, our perception of value levels is expanded. Our eye can discern many more value steps in a gradient of colors between white and black than in a neutral (gray) scale. When scaling a hue into a value scale, the natural or inherent value of each pure hue is lightened and darkened by tinting and shading the hue. We often hear the word "shade" to describe any type of color variation. To be precise in terminology, a shade always refers to a color mixed with black. The term *color shadings* is more appropriate to describe subtle color variations in, for example, a painting.

An accurate hand-painted value scale is achieved by controlling white and black pigments very carefully. Most students master this quickly. Students will find that their skill in color mixing and value perception improves simultaneously. In fact, most students will end up making many more colors than necessary for a ten-step hue value scale simply because they are able to mix and perceive the color distinctions more accurately as they work.

The traditional primary hues of red, yellow, and blue, and three secondary hues of orange, green, and violet, when scaled out modestly into ten steps each, make a range of forty-eight colors, not including black and white. The chart of hue value scales has value increments that align with the neutral gray scale. [3.8]

Value scales are a step-by-step representation of a gradation, which again also can be seen as a seamless transition between light to dark values. A gradient re-creates the play of light on objects.

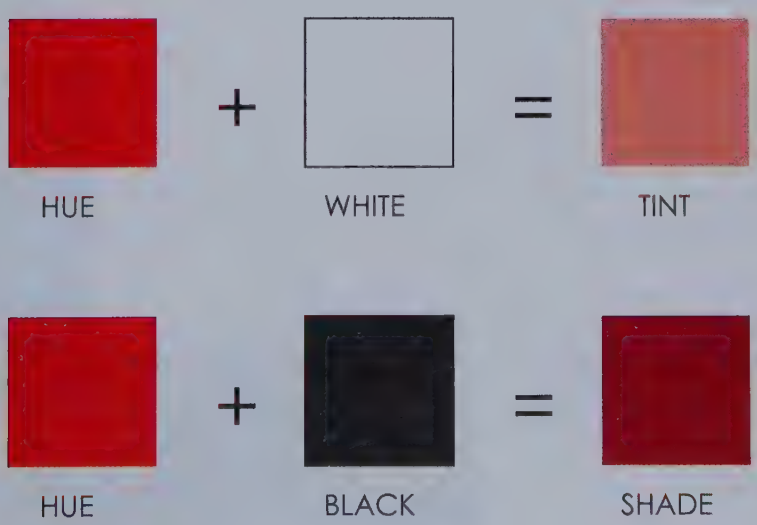


Figure 3–7 A tint is a hue + white and a shade is a hue + black.

Inherent Value of Hues

On the value scale chart shown here [3.8], the pure primary and secondary hues are located in different positions on each scale. The placement of pure hues diverges in each scale because each hue has its own unique light/dark value level, called *inherent value*. *Inherent value* is the light or dark value of a hue at its maximum saturation or purity. [3.9] Pure hues

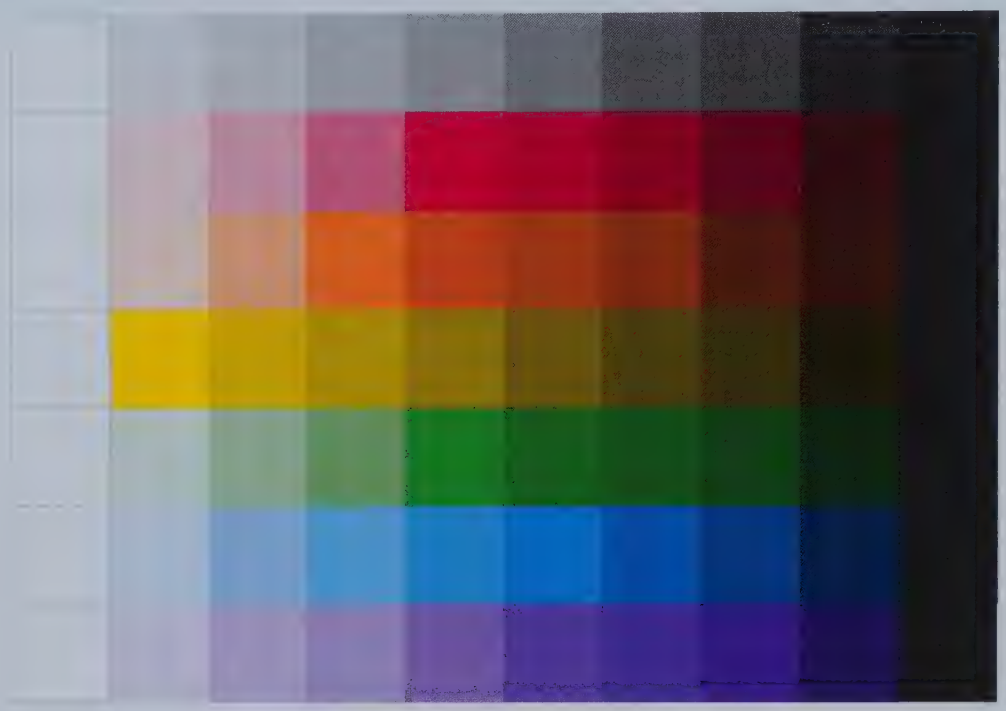


Figure 3–8 A primary and secondary tint/shade value chart; note the varied placement of pure hues in each value scale.

Figure 3–9 This chart shows the inherent value of hues. Notice that the layout of hues in this chart is identical to their placement in the traditional color circle. The lightest hues are at the top, and the darkest hues are at the bottom.

Figure 3–10 All the colors in this group are light in value key.

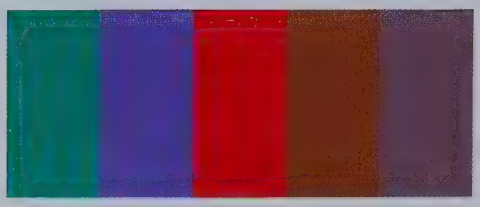


Figure 3–11 These colors are all value keyed to a medium-value level.

are positioned in different levels on each value scale to reflect their relative value. The hue placements on the color circle operate as a simple value guide. The position of yellow at the top of the color wheel designates its role as the lightest value hue. As we scan the wheel downward, the hues gradually darken until we get to the bottom, where violet is the darkest hue. Pure hues have an approximate light-to-dark range as follows: yellow, very light; YO and YG, light; orange and green, medium light; RO and BG, medium; red and blue, medium; RV and BV, dark; violet, very dark.

To identify pure hues solely in terms of value can be confusing and difficult. Most people tend to respond to a hue identity—its associations, personality, and characteristics. This is because it is difficult to separate the visual quality of a hue from its value. We react to the warmth of red, not to the fact that red is a medium-value color. On the value chart, the gray value scale aligns with the hue value scales to match the value sequence of each hue. [3.8] When students are working on value scales, the neutral gray scale can function as a value *key* or guide. For example, pure yellow is very close to white, pure red is approximately halfway between black and white, and violet is much closer to black because it is the darkest hue. Value/hue relationships are notoriously confusing for students. Most people want to believe that the pure hues have the same placement within each value scale, which would be convenient, but not accurate.

Value Keys

Steps in a color value scale can be imagined as keys on a value keyboard, a visual analogy for the concept of color value levels known as *keys*. High-value key colors' "notes" are light-value steps, inherently light hues, and tints. [3.10] Middle-value key colors are medium-value range hues and darker tints. [3.11] Low-value key colors' "notes" are the darkest hues and shades. [3.12]

When colors are *value keyed*, they are brought as close as possible to the same level or value key range. The process of keying values consists of selecting assorted colors and matching their light, medium, or dark levels very closely. When a diverse group of colors is keyed to the same value correctly, one color does not visually recede or come forward more than another. To determine colors that match in value, a group of colors may be viewed in a dimly lit room. A low-lighting situation makes it easier to see similarities in value, as low light decreases hue perception and increases light/dark sensitivity. Colors can also be keyed to any value level by manually mixing paint. A group of light value colors are created, for example, by tinting (adding white) a group of varied hues. Dark value keys are executed by shading hues to a similar dark value range. Attempting to key middle-value range colors is more challenging. Medium-value colors

Figure 3–12 Dark-value key colors.

tend to be purer, and it is harder for the eye to perceive the value differences in colors at full saturation.

SATURATION

The third characteristic of color is saturation. The attribute of color *saturation* refers to the purity or intensity of a hue or color. It is also sometimes referred to as chroma. High-saturation colors are pure, bright, and intense. Low-saturation colors are duller, subtle, and muted.

Saturation and Value

When manually mixing colored pigments, we are working with the subtractive color system. The greater the number of colors we mix together, the duller the potential mixtures become, due to subtraction. All color mixtures such as tints and shades are lower in color intensity than pure hues. Tinting shifts a hue to a lighter value level and, at the same time, lowers its saturation (intensity) level. Compare a pure red, for example, with a tint of red (pink), and we see that, although lighter, the pink is not as intense or pure as red. [3.8] When shading a red by adding black, the same effect occurs: The black both darkens and lowers red's saturation.

Students often have trouble differentiating the color characteristics of saturation and value. They will refer to a highly saturated red, for example, as "dark" red. A pure red is high in color saturation and medium in value. A dark *value* of red could possibly be a shade, a pure RV, or another dark mixture of red. [3.13] The concepts of value and saturation can be differentiated as follows: Value is the light/dark variable of color and saturation is the bright/dull variable of color.

Systems of Color Saturation—Color Solids

Throughout the history of color study, color theorists have systematized the concept of color attributes by formulating color solids. *Color solids* are three-dimensional color notation charts. Several theorists have devised color solids, notably Albert Munsell, Otto Runge, and Wilhelm Ostwald. Each of their color notation systems exhibits all of the attributes of color, hue, value, and saturation, simultaneously, within an organized framework. This group of color theorists felt that color solids were the optimal means of presenting all of the dimensions of color in a single visible structure.

ALBERT MUNSELL The foremost color theorist of this group was the American Albert Munsell (1858–1918). Munsell presented his color system in detail in the 1905 book entitled *Color Notation.* Munsell's color circle was based on ten rather than twelve hues.

Figure 3–13 Sometimes colors are mistakenly called dark, when in fact they are pure, high in saturation. The pure red is high in saturation and medium in value. Shades of red that are darker in value are also lower in saturation.

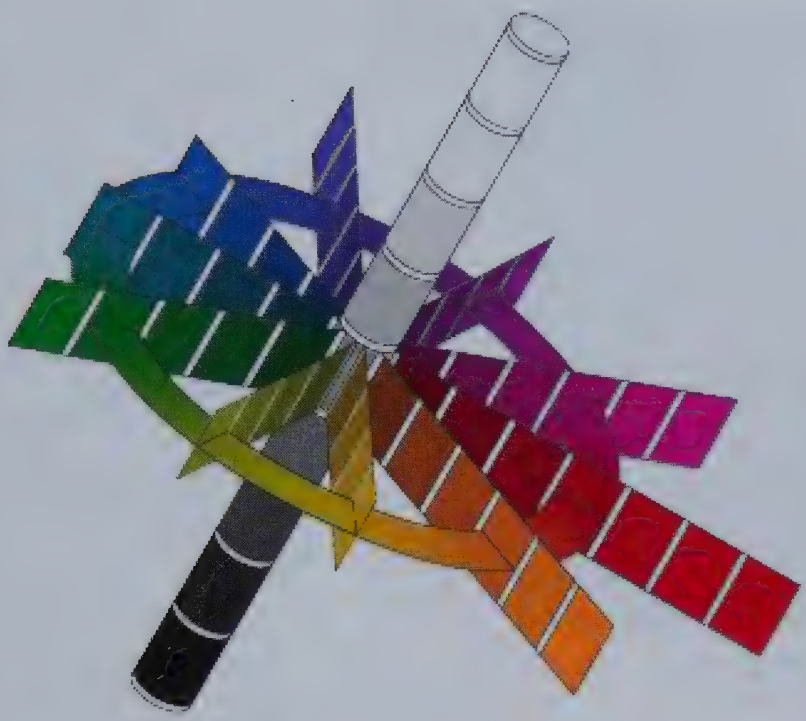


Figure 3–14 The Munsell Color Tree Schematic. Photo courtesy of Munsell X-Rite, Incorporated.

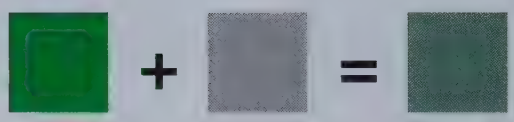


Figure 3–15 A hue plus gray is a tone.

Munsell's principal contribution to color theory was the development of a three-dimensional "color tree" that illustrated the color characteristics of hue, value, and saturation all at once. [3.14] In Munsell's color system, the pure hues are laid out in a three-dimensional circle surrounding a central core of a nine-step gray value scale. Each pure hue is located at a different level to be value aligned with each corresponding gray. Each pure hue graduates in steps toward the inner gray scale to concurrently reveal the tints, shades, and tones of each hue. Munsell's vision of interrelated color characteristics was realized through this three-dimensional color model.

Munsell coined the term *chroma*, a synonym for color saturation. A pure color in Munsell's system is regarded as having a high *chroma.* A *tone*, a hue + gray, according to his system, is a way of controlling the chroma of a color. [3.15] There can be many saturation steps from each pure hue to a perfectly neutral gray. In Munsell's color tree, each hue is scaled in sequential stages to white, black, and seven gray value steps. [3.16] An extensive and complex color system, the color tree was built to display the many variations of each hue to be perceived, created, and organized with relative ease.

WILHELM OSTWALD The research of German color theorist Wilhelm Ostwald (1853–1932) closely parallels the color theories of Albert Munsell. Ostwald's color notation system also emphasizes variety of saturation and is even more complex than Munsell's. Like Munsell, Ostwald created a color solid with a central value scale in an analogous relationship with a color circle. [3.17] Ostwald formulated an extremely scientific method of incrementally mixing pigments in order to achieve controlled results. Ostwald's color system is structurally more solid than the Munsell color tree but has a comparable method of pure hues gradating into a series of tones to illustrate saturation variety. The key difference between the two systems is that hues are aligned in a circle on Oswald's color solid, instead of being staggered by value as they are on Munsell's color tree.

PHILIP OTTO RUNGE An early color solid was developed by the eighteenth-century German color theorist Philip Otto Runge (1777–1810). Runge's elegantly designed color sphere establishes a twelve-hue color circle as an "equator" on the sphere with a central core of a middle-value gray. [3.18] Hues gradate in tonal steps toward the gray core. The

Figure 3–16 The Munsell color tree displays the three attributes of color in a three-dimensional form, indicating hue, value, and saturation. Photo courtesy X-Rite, Incorporated.

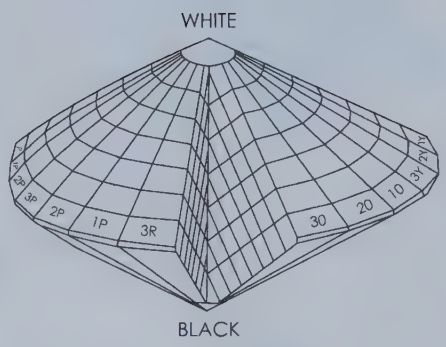


Figure 3–17 The Ostwald solid is similar to the Munsell color tree in its three-dimensional structure and its use of sequential tones.

Figure 3–18 The Runge sphere seen sliced in half along its equator; the sphere gradates into lower saturation tones toward a central gray core.

upper pole of the sphere is white and the lower pole is black. [3.19] The solid configuration connects tints and shades of the hues in correlation with the tones. The Runge sphere predates both Munsell's and Ostwald's color solids by almost a century and is perhaps a clearer presentation of similar concepts.

JOHANNES ITTEN Johannes Itten was an artist, color theorist, and teacher at the Bauhaus School in Germany. He developed a color study course that addressed the aspects, characteristics, and contrasts of color. In his book *The Elements of Color*, Itten designed a two-dimensional version of the Runge's color sphere in the form of a color star. The color star is essentially an exterior view of the color sphere, cut apart and spread out two-dimensionally. On the "equator" of the sphere are pure hues; its inner circle has tints gradating toward a white center, and the outer points have incremental shades towards black. A cross-section of Itten's sphere is based on Runge's design, with hue gradations toward an inner gray. The color star has a similar configuration to Moses Harris's color circle (2.5) but with white in the center and black toward the point of the star.

Methods to Vary Color Saturation

There are four principal means of controlling the saturation of a color, with pigments or digital color. The first and simplest method is to add a neutral to a hue, the second is to intermix complementary hues, the third method is to layer combinations of transparent colors, and the fourth technique is experimental hue-to-hue mixing.

Figure 3–19 The Runge sphere's outside view displays the pure hues on an equator that gradate toward white at the top pole and black at the bottom pole.

Figure 3–20 A simplified tonal saturation chart presents a pure color gradated to light, medium, and dark gray in a series of tones.

To effectively change the saturation of a color, one can simply add a neutral to a pure color to create a tint, shade, or tone. A *tone* is a hue plus some level of a neutral gray. As exhibited by the color systems of Munsell, Ostwald, Itten, and Runge, tones have a greater range of subtle color variations than either tints or shades. The tonal chart [3.20] shows a hue mixed with a light value, a middle value, and a dark value gray by gradating a neutral gray in incremental steps toward a pure hue. Tonal variations are created by mixing each hue in sequentially larger proportions toward any neutral gray value to effectively reduce saturation. Tones do not substantively change the character of a color; they permit colors to retain their identity even when scaled to a variety of saturation levels.

Color saturation can be also be manipulated by mixing a hue with its complement to mute or neutralize the hue. Complements neutralize each other because all three subtractive pigment primaries, RYB, are present in any complementary pair. For example, in the complementary pair of yellow and violet, violet is red + blue; thereby the pair contains all three pigment primaries, red, yellow, and blue. Painters mix complementary hues as a method for modulating a color. When mixed in the correct proportions and dyad pairings, each hue will completely extinguish its complement. [3.21] Complementary mixtures can control color saturation, creating neutral colors that are

Figure 3–21 Complementary Scales. When subtractive complements are mixed together, they lower the saturation of each other, ultimately forming chromatic neutrals. From top: red-green scale, yellow-violet scale, and blue-orange scale.

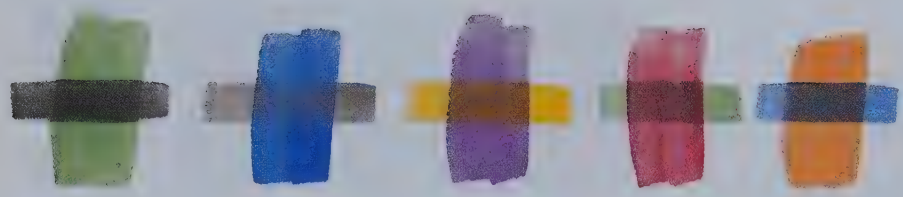


Figure 3–22 Transparent colors can be lowered in saturation by layering with neutrals or complementary colors.

called *chromatic neutrals.* Painters prefer chromatic neutrals because they are chromatically "cleaner" than gray-based tones, particularly when oil paint is used.

Transparent media, such as watercolor, printing inks, dyes, and markers permit layering of transparent colors on top of one another. A combination of colored layers may be used to lower the saturation of a color. Transparent neutral color layers such as black or gray can be placed over high-saturation colors, or complements can be layered atop each other together to reduce the intensity of any given color. [3.22]

When working manually with paint, intermixtures between hues may influence the saturation of a color, while producing many new colors. In hue-to-hue mixtures, subtle color changes result from mixing neighboring hues such as red and red-orange. More radical color changes occur when mixing hues that are spaced farther apart on the color circle, such as green and orange. Saturation changes can occur as a result of trial-and-error mixing. [3.23]

When working digitally, color saturation is variable in the S portion of the HSB, (which stands for Hue, Saturation and Brightness) color mode. This control provides a slider bar or numerical coding to easily regulate the maximum-to-minimum saturation of colors. Complementary mixing in CMYK mode, or mixing by adding black or white to a hue, can also lower color saturation.

Figure 3–23 Hue-to-hue mixtures can have many combinations to create new colors and vary saturation. In the top two rows, red to violet and yellow to green make a chromatic gradation between hues. On the bottom row, hues that are widely spaced apart on the color circle change more in color and saturation when mixed, such as blue mixed with YG. Courtesy of Becky Koenig.

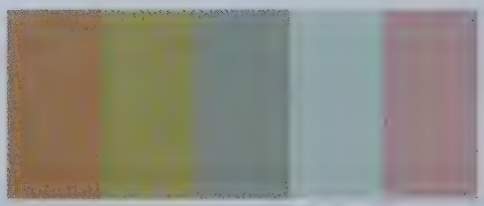


Figure 3–24 Low-saturation key colors are colors that are duller or muted.

Figure 3–25 High-saturation key colors are colors that are very intense or pure.

Saturation Keys

The concept of color keys pertains to color saturation as well as to color value. The terms used here are slightly different: Color *saturation keys* are referred to as high-, medium-, or low-saturation colors. Low-saturation colors are dulled or neutralized. [3.24] Middle-saturation colors are medium intensity or partially muted. High-saturation colors are full-intensity, pure hues or strong colors. [3.25] Some artists prefer to work in a high-saturation key, others use mostly low-chroma or saturation colors. [3.26] Still others use saturation contrast to draw the eye to specific areas of a composition.

The three attributes of color—hue, value, and saturation—can be manipulated to control and generate a wide range of colors. Color solids notate all the dimensions of color, reflecting the almost infinite possibilities of color.

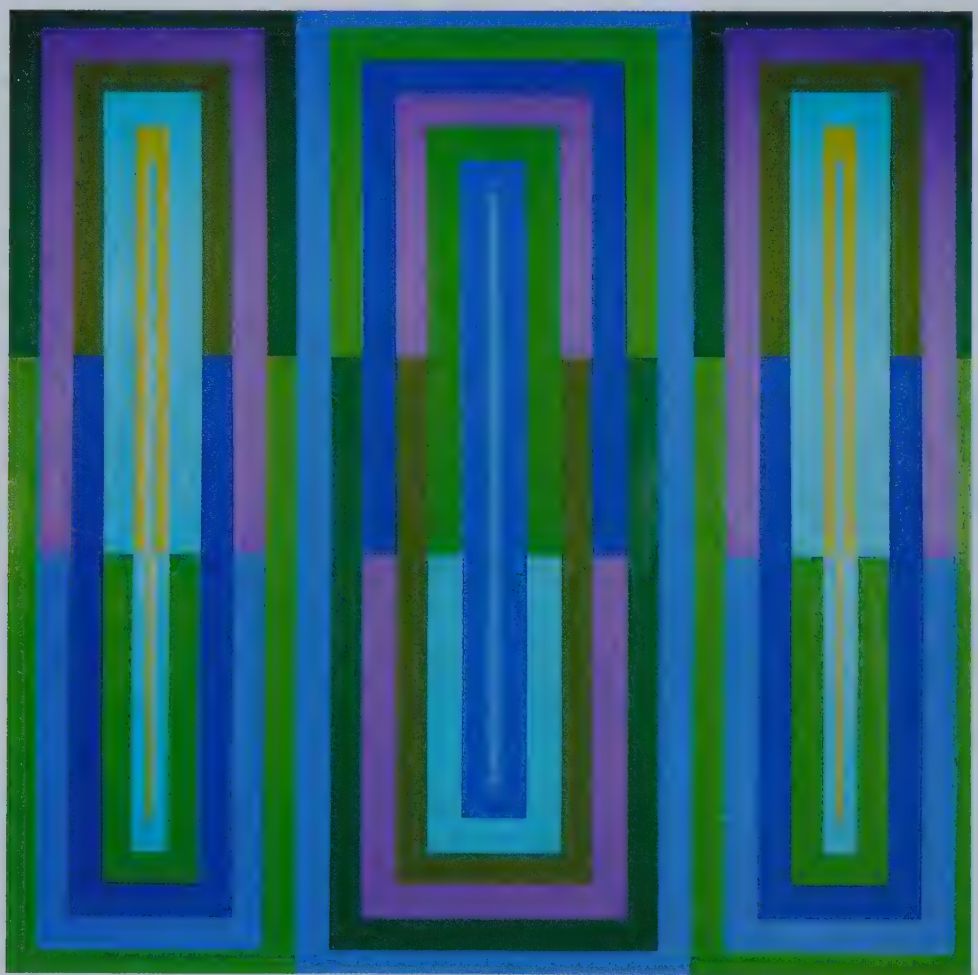


Figure 3–26 James R. Koenig, Ribbon Structure, acrylic on canvas. 1973, Collection Becky Koenig. © James R. Koenig. This painting displays mainly high-saturation key colors.

Activities

1. Hue Identification and Variety Studies

Objective: The objective of these studies is to train the eye to correctly identify a color in relationship to its base hue on the color circle. Additionally, the student should be able to produce and identify a group of colors generated from this base hue that remain in the hue family.

A. Hue Identification Study

- Using Color Aid® paper, found color paper, samples from a paint store, or other materials, gather as many varieties as possible of one base hue (any primary, secondary, or tertiary hue), such as violet.
- Go through the assorted colored papers, identifying the colors one by one. Light colors should be identified on a pure white background, and dark colors can be identified against a pure black background. Make sure to identify each color sample one at a time, not as a group. This exercise seems to be rudimentary, but is in fact quite complex. An even greater challenge is the identification of colors that are very muted, neutral, and dull; very dark value colors; and very pale colors.
- All colors should be visually identified as having the same base hue that you have chosen. [3.27, 3.5] For example, for green, there should be muted tones, strongly saturated pure colors, light tints, dark shades, and slightly more yellow and slightly blue-green varieties.
- The format is ten 1″ × 2″ rectangles placed in a 4″ × 5″ format as shown. The colors should be arranged to maximize contrast and variation.

B. Hue Variation Study

- For this study, mix a group of colors based on the same hue with paint. The difficulty of this exercise is to vary the hue by physical paint mixtures without jumping into another hue category.
- For these color variations, begin with any primary, secondary, or tertiary hue. Make various tints, shades, and tones based on that hue. Make some hue-to-hue mixtures, being sure that your chosen hue still dominates the color mixture. For example, blue can be mixed with small amounts of red or orange, without allowing the mixtures to become violet. These mixtures, in turn, can be tinted or shaded.
- Present the hue variations in the same manner as above.

Figure 3–27 A hue identification study on green has a wide variety of colors based on a green hue.

2. Value Studies

Objective: The student should understand and manipulate the concept of neutral value and color value.

A. Value Scales: Neutral Gray Value Scale

- In this exercise, there are four value scales.
- The first scale is a gray scale of ten or twelve steps including white and black.
- Mix at least fifteen to eighteen possible steps from white to black, painting them on good sketch paper. The paint should be opaque and evenly applied, approximately 2 inches square.
- When mixing light values, start with white and gradually add black. When mixing very dark values, start with black and gradually add white.
- When the paint is dry, cut the swatches into 2″ × 2″ squares. Remove the white paper from one edge on each swatch and overlap the pieces in order, creating a color scale.
- Edit the scale down to ten or twelve even steps. Take care that there are no abrupt jumps in value.
- Assemble the swatches, according to the directions, into a scale of ten 1 inch adjoining squares. [3.28]

B. Primary Tint/Shade Scales

- Make a value scale using each of the three subtractive primary hues: red, yellow, and blue.
- Make ten- or twelve-step scales, including black and white.
- Paint out a swatch of each primary hue to be included in each of these scales.
- Mix tints of the hues (by adding white) and shades (by adding black), at least six of each.
- To mix tints of a hue is to mix the pure hue in steps to white, and for shades, the pure hue in steps to black.
- When you are making light tints of red, start with white, adding small amounts of red. For the darker tints, start with red and add small amounts of white.

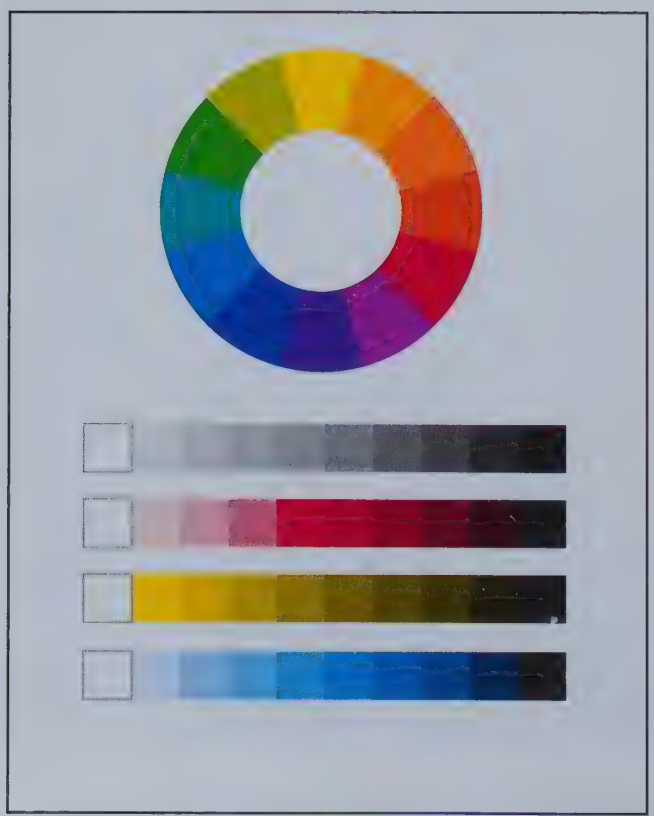


Figure 3–28 Color circle and value scale studies presented together.

Figure 3–29 A guide for making scales. Use grid paper and overlap swatches, then cut as shown.

- For shades, start with the hue, such as red, and add small amounts of black in stages; otherwise, the black will completely cancel out the hue.
- Do not add both black and white to your hue; this makes a tone.
- Cut away the white edge on each swatch of color and overlap the pieces in order. If there are large jumps, mix a shade or tint to fill the gaps. Select scale down to ten to twelve even steps, including black and white, finding the appropriate placement for the pure hue.
- Assemble scale as shown in the illustration.
- Make a separate scale each for red, yellow, and blue. Present all scales on a black or white board with the neutral gray scale.

C. Scale Assembly Instructions

- The easiest way to assemble scales is by using grid paper as a guide.
- Make sure that each color swatch has one straight edge.
- Use the grid paper as a guide for overlapping swatches at 1 inch increments as shown, gluing them onto the grid paper as you go.
- Glue each swatch onto the grid paper until the whole scale is complete. Then trim the scale strip from the back to a 1 inch–wide strip using the grid paper as a guide to form 1″ × 1″ squares. Grid paper can be used as a guide for the 1″ × 2″ pieces as well. [3.29]

D. Additional Value Exercises

Mixed Color Value Scale

- Make a value scale of ten or more steps using Color Aid® or found paper. In this scale use various hues and colors and try to put them in order sequentially from light to dark.

Keyed Value Grids

- Make keyed-value grids. Using found or Color Aid® paper, pick various hues that are as close to the same value as possible. Use the same 1″ × 2″ grid format as the hue variations for these studies. A grid of all light-value key colors, one of medium-value key colors, and one of dark-value key colors can be made. Looking at colors in a half-lit room will aid this process. [3.30]

Arbitrary Value

- Make a grid or pattern structure (diamond grid, stripes, etc.) that uses one hue and its tints and shades. Lay out the colors in an arbitrary arrangement. Then analyze the spatial aspects of the piece. Which colors seem to visually advance and which recede? Why does this happen? [3.31]

Value Color Gradient

- Create a gradient or blended version of one of the hue value scales with drawing materials such as colored pencils or pastels. Try to create the most even blend: for example, from white to the hue red, then red to black.
- The same scale can be created digitally using the gradient tool on a graphic program. [3.32]

Figure 3–30 A value key grid of all light-value colors.

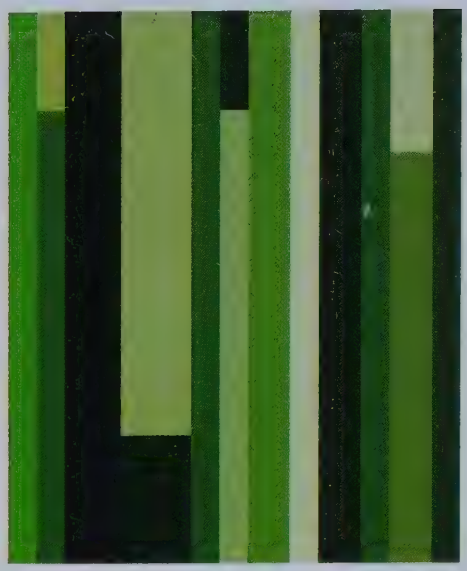


Figure 3-31 Arbitrary Value Study—by using values of a hue in an arbitrary manner, we can see how pure and muted or light and dark values can suggest space as some colors will advance and some will recede.

Figure 3-32 A digital gradient, above, and a handmade value gradient, below, that can be made with colored pencils or pastels.

Value Color Forms

- Make three or four simple shapes into volumes to render with drawing materials, in paint or digitally. The forms can be reality-based or invented.
- To give the shapes volume, use a hue scale with tints and shades as a reference to render the form with a sense of light. Make several of the forms in different hue scales. [3.33]

3. Saturation Studies

Objective: For the student to understand and manipulate the concept of color saturation and use a modified approach to the Munsell color system.

- Pick any primary or secondary hue and paint out a swatch of the pure hue.
- Mix three neutral grays, one light value, one middle value, and one dark value.
- Make a simple tonal scale of about five or six steps from the hue to each gray. You will probably have to mix more than five to get even steps. The steps should represent the hue gradating to each gray value. This exercise forms a family of related tones from one hue.
- The hue will still be recognizable as it gradates toward gray, but the colors will become lower in saturation and may change in value. For example, an orange will change in value and intensity when dark gray is added to it. Light gray will make orange only lose its intensity.
- Present as illustrated. [3.20]

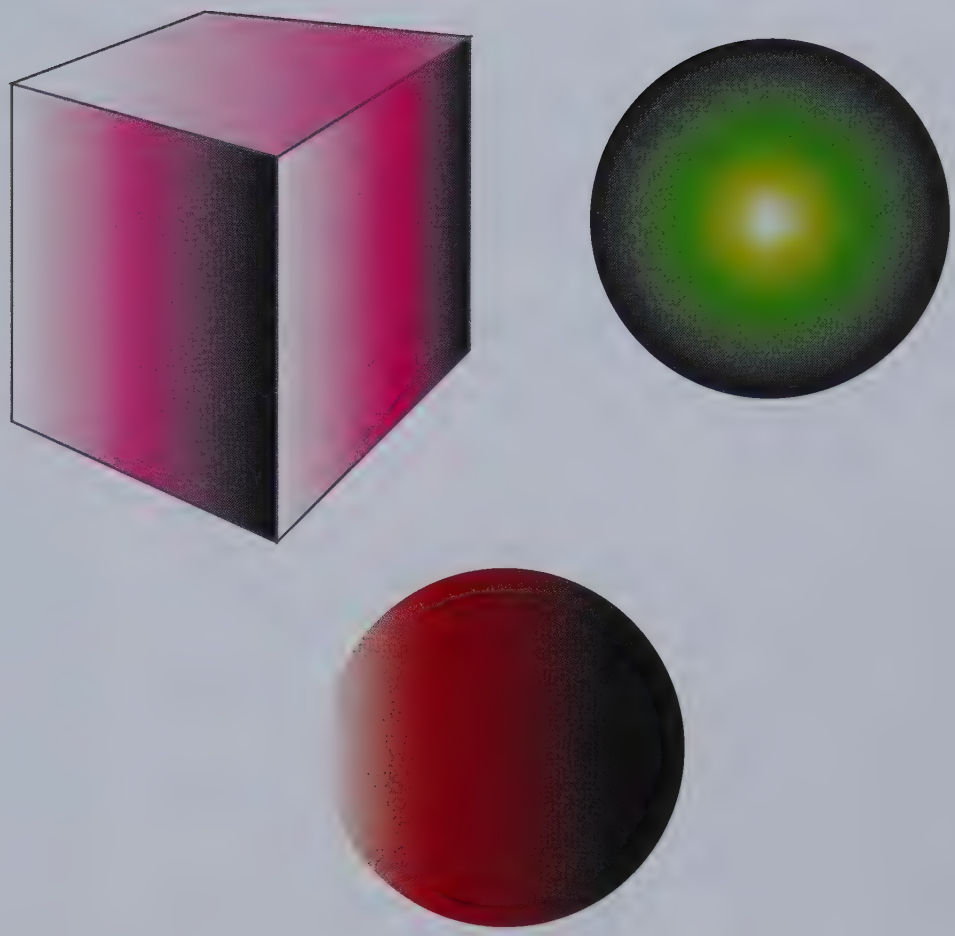


Figure 3-33 The volume of forms can be expressed through value gradients as shown.

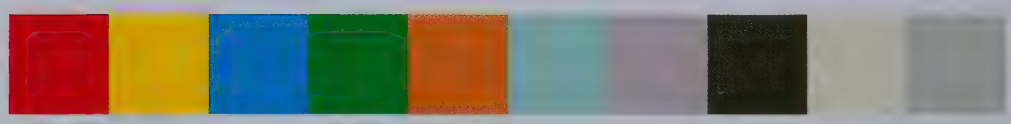


Figure 3-34 A saturation scale of different colors arranged in order of their saturation or purity, from intense to muted.

A. Additional Saturation Exercises

Mixed Color Saturation Scale

- Using Color Aid® or found colored papers, make a saturation scale from varied colors and hues. The scale should range from the strongest, most saturated colors to the dullest, most muted colors. This scale will represent high-, middle-, and low-key saturation or chroma. Remember to go from brilliant to dull rather than from light to dark. [3.34]

Saturation Key Grids

- Using the same format as the hue variation studies, make a grid of high-saturation key colors, middle-saturation key colors, and low-saturation key colors. Any colors can be used, but they should "match" in intensity level; try to visually equalize each grid. This exercise may be done on a computer using the saturation slider bar in HSB color mode with any graphics program.

Glossary

Achromatic Achromatic colors are neutrals, meaning that they contain no chroma or hue. An achromatic color scheme uses all achromatic or neutral colors, black and white, and a full value tonal range of grays.

Base hue A hue from the color circle to which a color is derived; its source hue. The concept of a base hue means that the thousands of colors that we perceive can be traced back to the twelve hues on the traditional color wheel.

Chroma A term coined by Albert Munsell, which is synonymous with saturation or intensity; high chroma is high intensity, low chroma is low intensity.

Chromatic neutrals Subtractive intermixtures of complementary hues that create neutral colors based on chromatic, rather than achromatic, colors.

Color attributes The variables or characteristics of color, which are hue, value, and saturation.

Color keys The notes on a piano keyboard are analogous to the concept of color keys. Two types of color keys are value keys, which are levels or light (high) to dark (low) colors, and saturation keys, which are levels of pure to muted colors.

Hue Hue means any wavelength from the visible spectrum. A hue is a specific color selection from the spectral color circle in its pure state, sometimes referred to as a spectral hue. Hues may be a primary, secondary, or tertiary color.

Inherent value The light/dark value of a pure hue at its maximum saturation.

Saturation The property of color that refers to its purity, intensity, or chroma. High-saturation key colors are pure, bright, and intense. Low-saturation key colors are duller, subtle, and muted.

Shade A hue plus black, which makes a darker value of a hue.

Systems of color notation Color theorists have developed various systems of notation for the three color attributes of hue, value, and saturation.

Tint A hue or color plus white, which makes lighter values of a color or a hue.

Chapter 4

Color Interaction

LEARNING OBJECTIVES

- For the student to understand the relative nature of color, how color is visually affected by the influence of other adjacent colors. The theory of Josef Albers is explained and activities are explored to illuminate these theories.
- Other types of related color relativity concepts are also explained and utilized as follows: optical mixtures, the Bezold effect, and actual and illusionary transparency.
- For the student to understand the importance of color interaction in all types of functional color relationships.

INTRODUCTION

Color study traditionally covers the origin and physics of color, the attributes of color, and color systems. None of this information, however, addresses the phenomenon of relative color that is called color interaction. Color interaction is an illusion that occurs within our perception of color. The concept of *color interaction* is based on the notion that color perception is dependent on color relationships. We rarely see colors as independent entities in reality or in art because color is frequently seen and used in context of other colors. Our visual reality is composed of color masses in juxtaposition to each other, and through these color combinations we perceive colors in interconnected relationships. Color relationships are ever changing, and the appearance of color will fluctuate as a consequence of these interactions. The manner in which colors interact is a mysterious yet fascinating area of color study. The mastery of color interaction, how colors influence each other, is integral to the creation of art and design.

COLOR RELATIVITY—CHEVEREUL AND ALBERS

Simultaneous Contrast

Because color is a phenomenon that exists in the human brain, our individual experience guides the perception of color. Each person's concept of red, for example, is distinct and varies from one person to another regardless of any international color standards. Perception of a color depends upon its visual context—colors that might touch or surround each other and the effect of lighting. For instance, the color of a pink (a tint of red) flower will have one appearance in bright sunlight and another color effect in shadow. To alter the color surroundings and lighting conditions of the pink flower may change the visual effect, resulting in several varieties of pink. Which pink, then, is the "true" color of the flower? The appearance of pink (or any color) is dependent on its visual surroundings, which demonstrates the ambiguity and relativity of color.

Artists have always been cognizant of the concept of color relativity. Painters are familiar with a color's capacity to alter its appearance from the palette to the context of a painting. In the Renaissance, Leonardo da Vinci observed that color perception is dependent on the interrelationship of color groupings in a work of art.

The French chemist Michel Eugene Chevereul (1786–1889) explored the idea of color relativity in detail. Chevereul was a supervisor of dye production in a carpet-manufacturing plant. In the course of his work, Chevereul discovered that often colors failed to produce their anticipated effect within the pattern of a carpet. He soon realized that the difficulty was not chemical but optical. The inconsistencies in human

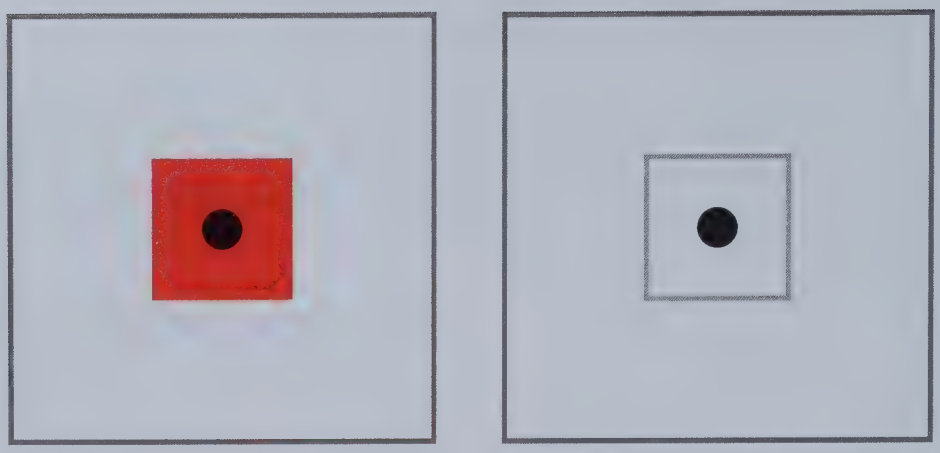


Figure 4–1 Afterimage. Try this experiment to understand the phenomena of afterimage. Stare at the dot in the RO square and then quickly switch to the blank square. What do you see?

color perception led to Chevereul's research and theories, presented in the 1839 book, *The Principles of Harmony and Contrast of Colors.* This book puts forward the rationale that color perception is affected by fluctuations in color relationships. Chevereul discovered and coined the term *simultaneous contrast. Simultaneous contrast* can be *generally* defined as the manner in which colors interact and affect each other. When colors interact, they are capable of changing in appearance, depending on particular relationships with adjacent or surrounding colors. This concept is strongly tied to the phenomenon of afterimage. [4.1] An *afterimage* occurs when the eye grows tired of a given hue and spontaneously creates the visual complement of the hue. For instance, after staring at RO and quickly shifting our eyes to a blank white sheet of paper, the eye will spontaneously produce a momentary afterimage of BG. This phenomenon is also known as *successive contrast* since an afterimage occurs in direct succession to the eye's overexposure to a full-saturation color. A more specific definition of simultaneous contrast accounts for the phenomenon of afterimage. In this context, simultaneous contrast means that the eye simultaneously "wants" to see the complement of any given hue for color balance. The eye spontaneously generates the complementary color even when the hue is absent.

Chevereul concluded that afterimage is so pervasive that one color will "push" a second adjacent color toward the complement of the first color. This type of color interaction is dependent on the direct proximity of adjacent colors. For example, in the illustration, YG causes violet to appear to be more RV. YG pushes violet toward RV because RV is the complement of YG. The YG, surrounded by violet, appears to be more yellow because yellow is the complement of violet. [4.2] A simultaneous contrast illusion is most pronounced when one color is completely surrounded by another.

Figure 4–2 Simultaneous Contrast. Left: The violet appears to be more RV near the YG since YG is the complement of RV. Right: The YG may appear slightly more yellow in relation to the violet since yellow is the complement of violet.

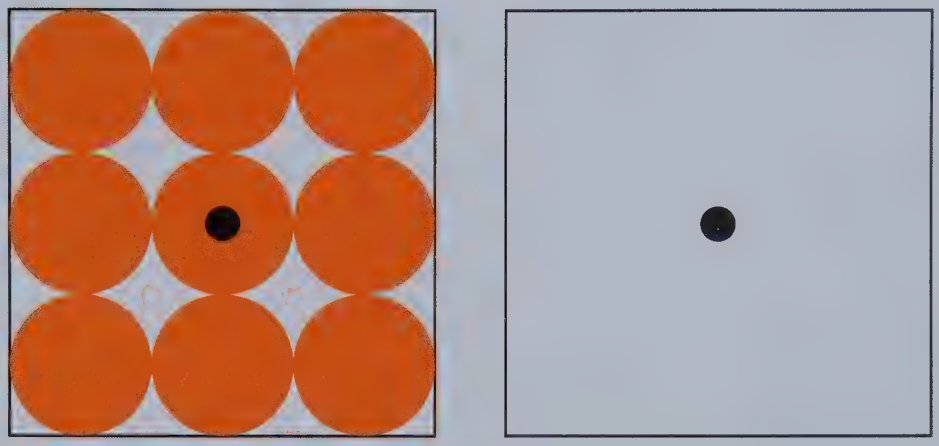


Figure 4–3 Contrast Reversal. Stare at the dot amid the orange circles and then quickly shift to the dot in the blank square. What do you see? See the text for an explanation.

Afterimage

Why do we see an afterimage of a color? Why don't we see it all the time? First of all, an afterimage is usually only perceptible in a controlled or extremely strong color situation. Otherwise, we would be seeing distracting afterimage colors all the time. An afterimage occurs due to fatigue in the hue sensors (cones) in our eye. This forces our eye to revert to the other remaining hues to which our eye is sensitive. So, when the red L-cones in our eye tire of a strong red, the eye reverts to the two other remaining cones, M and S, green and blue, respectively, which then form a brief sensation of bluish green. Thus, we may think of afterimage as a color overload or reaction. "Negative" afterimages, tied with the research of Chevereul, were first investigated by Robert Waring Darwin, the father of Charles Darwin.

Figure 4–4 Simultaneous Contrast. The complementary effect is so pervasive that it influences even neutral grays. Note that each gray is tinged with the complement of each ground color. For example, the gray on the orange ground appears to be bluish.

In this experiment, the afterimage is so strong that it actually works in reverse. Stare at the dot in the illustration of circles and then quickly shift to the other dot on the white surface. Can you explain what you see? This afterimage effect is called a *contrast reversal.* [4.3] While we are staring at the orange circles, our eye is filling in the white spaces with blue, although we cannot perceive this. Thus, when we look at the blank square, the white spaces between the orange circles reverse again from a blue afterimage to the complement of blue, making orange shapes.

The effects of afterimage and simultaneous contrast are so pervasive that they can even influence our perception of neutral colors. [4.4] All the grays in the illustrations are the same perfectly neutral gray. However, there are slight variations on the appearance of each gray based on their hue grounds. Gray on the red ground appears to have a greenish tinge since our eye "wants" to see the complementary hue of red. The same gray on an orange ground displays the most striking effect, seeming to have a bluish cast. Simultaneous contrast causes this color distortion because of our need to see the blue-orange complement in balance. The same gray has a subtle reddish quality on green, a yellowish cast on violet, and an orange tinge on blue. In this manner, the theory of color interaction centers upon the effects of simultaneous contrast and afterimage.

Simultaneous contrast has also been the subject of artwork, mainly in an art movement called *Orphism,* a term coined by the French poet Apollinaire in 1912. The French artists Robert and Sonia Delaunay (Robert, a painter, and Sonia, a painter and designer) were the principal proponents of this art movement, also known as *Orphic Cubism.* The Delaunays manipulated theories of simultaneous contrast in abstract paintings. By juxtaposition of complementary hues, the colors were meant to create a sensory effect of rhythm, light, and movement. The painting shown here is a work entitled *Sun and Moon* [*Soleil, lune, simultané 2*], 1913, by Robert Delaunay, who composed the painting with the suggestion of an illuminated sunlike and moon area but, most importantly, used circular areas of hues and colors grouped into complementary contrasts. [4.5] Robert

Figure 4–5 This painting by Robert Delaunay presents combinations of contrasting complementary hues to generate dynamic movement through color. Robert Delaunay, *Simultaneous Contrasts: Sun and Moon* [*Soleil, lune, simultané 2*], 1913-dated on painting 1912, Oil on canvas, 134.5 cm in diameter. The Museum of Modern Art, New York, Mrs. Simon Guggenheim Fund, Digital Image © L&M Services. The Museum of Modern Art/Licensed by SCALA/Art Resource, NY.

Delaunay collaborated with his wife Sonia, a designer, and both of them sought to represent the theories of Chevereul via painting and modernist design.

Albers and Color Interaction

Josef Albers (1888–1976) was a German painter, educator, and color theorist. He taught at the Bauhaus School in Germany prior to World War II. The Bauhaus School was a seminal art institution that melded fine art, design, crafts, and architecture. Albers later came to the United States, where he taught at Yale University. Albers probably would not have considered himself a color theorist in the traditional sense. His educational method was first to visually sensitize students to color before they learned about traditional color systems and charting. Albers's significant contributions to color education were presented in a famous book, *The Interaction of Color*, published in 1963. In his book, Albers outlined specific color exercises for students, focusing primarily on the notion of color interaction. Albers stated that one color could have many "readings," depending on both lighting and the context in which the color is placed. He felt that a grasp of color relationships and interactions was fundamental to acquiring an eye for color. Albers's ideas were based on the research of Chevereul as well as his extensive classroom experience and experimentation.

Josef Albers also put his ideas about color into his own paintings. In 1949, he began a series of paintings entitled *Homage to the Square*: classic formalist works on the subject of color groupings that he produced throughout his life. In this body of paintings, Albers persistently and elegantly explored shifting color relationships between hues, value, color temperature, and saturation in a quest for ever-changing color harmonies. [4.6]

Figure 4–6 Josef Albers's works explored color interaction in a series of paintings and prints entitled *Homage to the Square* (1962), Josef Albers. Portfolio of ten screenprints, composition (.3): 11-1/16" × 11" (28.1 × 27.9 cm); sheet: 16 15/16 × 16 7/8" (43 × 42.9 cm), 1962. The Museum of Modern Art, NY/Licensed by SCALA/Art Resource, NY. © 2011 The Josef and Anni Albers Foundation/Artists Rights Society (ARS), New York.

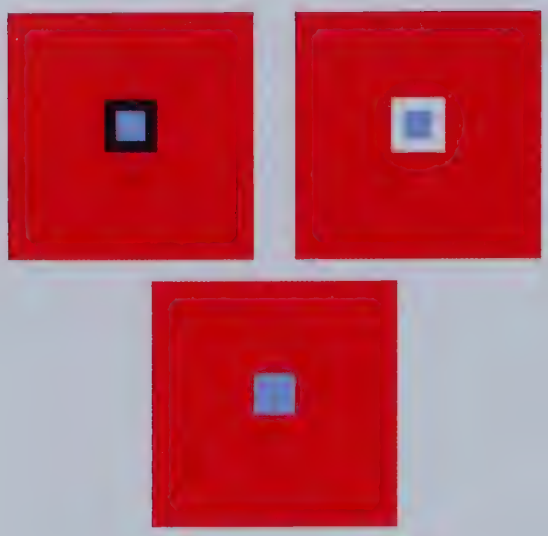


Figure 4–7 Color interaction studies should show direct interaction of adjacent colors. Black outlines seem to constrain colors, while white outlines isolate and expand color.

Color Relativity—Principles of Color Interaction

Because of the strength of his color teaching methodology, many color classes are based solely on Albers's experiments and studies. Albers's methods are direct and meaningful, and they sensitize students to color. Several important factors can be gleaned from *The Interaction of Color.* To streamline the comprehension of Albers's outlook, as well as position his ideas into the larger context of color study, his concepts can be simplified into key principles.

According to Albers, we rarely see a color that is not affected by other colors. Even when a color is placed against a pure neutral of black, white, or gray, the color is influenced by that neutral ground. The study of color interaction entails a series of color "experiments" that enlighten our knowledge of how colors function in relationships. The color transformations that can result from these experiments are both striking and surprising.

For color interaction experiments, a relationship between two colors must be unequal, in which one color dominates another. Colors do not necessarily need to be dominated in order to be modified, but dominant color relationships dramatize our perception of color shifts. The ideal setup is a relatively large ground color in proportion to a much smaller area of the color to be affected. A smaller area of color is strongly affected because a large environment of color surrounds it. Colors for interaction studies also must be directly adjacent to one another without white or black outlines. [4.7] Color interaction is minimized by the containment of outlines.

Colors interact and are modified in appearance by other colors in accordance with three guiding rules or concepts. These rules are called the *principles of color interaction.* These principles function either separately or simultaneously. The rules are presented in order of conceptual difficulty.

Principles of Color Interaction

1. Light/Dark Value Contrast
2. Complementary Reaction or Effect
3. Subtraction

Light/Dark Value Contrast The first principle of color interaction is light and dark value contrast. The most efficient way to effect a color change is to utilize the principle of light/dark value contrast of grounds. Logically, a color will appear lighter on a black or dark ground and appear darker on a white or light ground. A light or dark value environment affects even an achromatic color like gray. The gray scale that is shown

Figure 4–8 This gray scale illustrates how even achromatic colors can change our perception of value by color relationships. The gray circle inset in the gray scale is all the same value gray, which seems to change in comparison with the surrounding values.

here has a circle of an identical gray value running through it. [4.8] Note the striking alterations in the appearance of the same gray value throughout the scale.

Colors also react in a similar manner. For instance, red on a black ground seems to be both lighter in value and less heavy when compared with the same red on a light gray surface. On a light gray ground, red seems to be both darker and denser in saturation. [4.9] Colors appear to be lighter in value on dark grounds due to the comparative relationship between them. Similarly, colors appear to have a darker value on light grounds due to contrasting value relationships. A dramatic example, shown here, is the same light value BV presented on both a dark blue ground and a light blue ground. It is difficult to tell that both blue violets are exactly the same; the blue violet on the dark ground seems to be much lighter.[4.10] A similar effect occurs with a stronger color such as a pure green hue. [4.11] In this manner, light/dark value contrast controls the perceptible value level of a color.

COMPLEMENTARY REACTION OR EFFECT The second principle of color interaction, called *complementary reaction or effect*, is a bit more complex. This principle exploits the concept of simultaneous contrast, a strong factor in color interaction. Remember that our eye "seeks" the complement of any given color, especially high-intensity colors. For this reason, an orange on a blue ground appears to have a higher saturation or intensity when compared with the same orange placed on a neutral gray ground. [4.12] The complementary effect causes a color to "bend" toward the complement of a ground or dominant hue. Our eye causes the high-saturation blue to make us "want" to see orange because it is a complement of blue, for hue balance. This effect enhances the orange and makes it seem to be more saturated.

In the second example, YG on a violet ground appears to have a more yellow cast than the same YG on a neutral gray ground. This illusion occurs because when we perceive violet, we simultaneously "seek" yellow, violet's complement, so YG is pushed slightly

Figure 4–9 Color Interaction. Colors appear to be visually different depending upon their context. Red appears lighter on black but heavier and darker on light gray.

Figure 4–10 Value Contrast Principle. This tint of BV seems to be lighter on dark blue and darker on light blue.

Figure 4–11 In this use of value contrast, the green seems lighter on a dark gray and darker on a light value gray.

Figure 4–12 Complementary Reaction. Orange appears more intense on the blue ground when compared to how it looks on gray. This is caused by the complementary effect.

Figure 4–13 YG appears more intense on violet due to complementary reaction.

toward yellow. The principle of light/dark value contrast is also in play here. The YG appears to be lighter against the dark value of violet than it is on the paler gray ground. [4.13]

SUBTRACTION The last principle of color interaction is the rule of subtraction. This is perhaps the most difficult idea of the three principles to grasp. According to this concept, a strong or dominant color will actually subtract itself from a smaller or less dominant color. For example, a YO on an orange ground seems to be less orange, leaving it more yellow, when compared with the same YO on a neutral gray ground. The dominant color, orange, is subtracting itself from the YO, leaving a visual effect of simply yellow. In comparison, the YO also appears to be more orange against a gray ground. [4.14] The influence of the orange ground changes YO slightly in hue and lowers its saturation due to subtraction. In this manner, subtraction can slightly change a hue as well as the saturation of a color.

COLOR SUBTRACTION EQUATIONS The principle of subtraction can become rather complex. Therefore, we might regard color subtraction as a color equation. The equation, for example: YO − O = Y explains briefly the color change in the previous example. In a second example, the same RV is placed on both a red and a violet ground. [4.15] The RV in the red environment looks more violet according to this equation: RV − R = V. The RV on the blue ground looks redder according to this equation: RV − V = R. This study proves that by the careful manipulation of a color's surroundings, even the base hue of a color can be altered.

Subtraction may also operate in the following manner. When an orange is placed on a dominant YO (shade) ground, the yellow will subtract its own component from the orange as follows: YO − O (Y + R) = R. [4.16] This forces the orange to appear slightly

Figure 4–14 Subtraction. YO seems to be somewhat yellow on an orange ground due to subtraction. The orange subtracts itself from the YO, leaving more yellow.

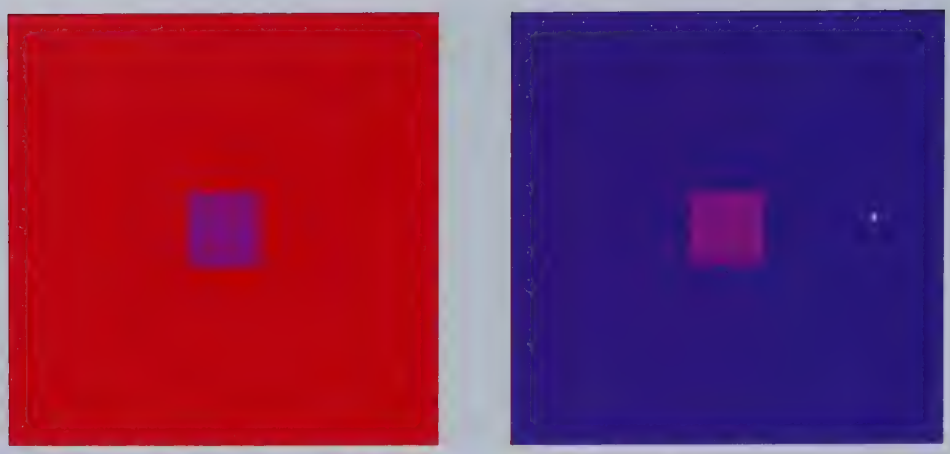


Figure 4–15 RV on a red ground appears to be more violet. The same RV on a violet ground appears to be redder. Both effects are caused by subtraction.

redder. The same relationship, when inversed, changes the color dynamic. When YO is placed on an orange ground, the equation follows: O − (R + Y) = Y. The strong orange ground causes the red component to be subtracted from orange, leaving us with a stronger visual impression of yellow. In this manner, even saturated hues can be visually distorted as a result of their color environment.

ALBERS'S STUDIES To demonstrate the principles of color interaction, Albers designed two color study experiments, which are classic in their simplicity yet serve to illuminate the idea of color relativity. Prior knowledge of color interaction principles is crucial for execution of Albers's color interaction studies. These studies are perhaps simplest when made with colored paper. When choosing the colored grounds, we should try to pick colors that are very different in both hue and value. This exercise is fairly easy to do. Often, the student has great success with the first study by trial and error without fully understanding the three principles of color interaction. However, to truly comprehend color relativity, students should attempt to explain why their color experiment works, by citing specific principles. Some colors react intensely to color surroundings and others resist change. For instance, very saturated or warm colors can be very hard to change. A full-saturation yellow, in particular, resists being changed in appearance under many circumstances. In contrast, most low-saturation colors change easily. Experimenting with a wide variety of colors ensures success.

In the first study, the goal is to *make one color appear to be two colors* by changing the color of the ground or context color. Two examples of the first Albers study are

Figure 4–16 Examples of Subtraction. In this case the colors are in an inverse relationship to demonstrate subtraction. The orange on the YO ground seems slightly more red; the YO (shade) on the orange ground seems slightly more yellow.

Figure 4–17 Value Contrast and Subtraction. Light violet appears to be more saturated and darker on a yellow ground. The same color looks lighter and less saturated on a dark violet ground due to subtraction, value contrast, and complementary reaction.

presented here. The first example exhibits all of the three principles. [4.17] A light violet appears to be darker on the yellow ground because of the light value of yellow. The violet also seems to have a higher saturation (to be stronger violet) on the yellow ground due to complementary reaction. Remember, we "want" to see violet when we perceive yellow, thus the violet hue is enhanced. The same light violet appears to be even paler and duller (lower in saturation) on a dark violet ground. Subtraction occurs here; the strong violet ground subtracts itself from the light violet, lowering its color intensity. Both of these colored grounds have effectively changed our perception of the violet color in two ways, shifting both its value and intensity.

The second classic Albers study is to *make two different colors look like one color* by the illusion of color interaction. This is a more challenging study to execute. When choosing two different colors for this study, one may select two value steps of one hue, two slightly different hue variations such as blue and BG, or two different saturation levels of the same color. Logic, as well as a grasp of the color interaction principles, makes this study easier to execute.

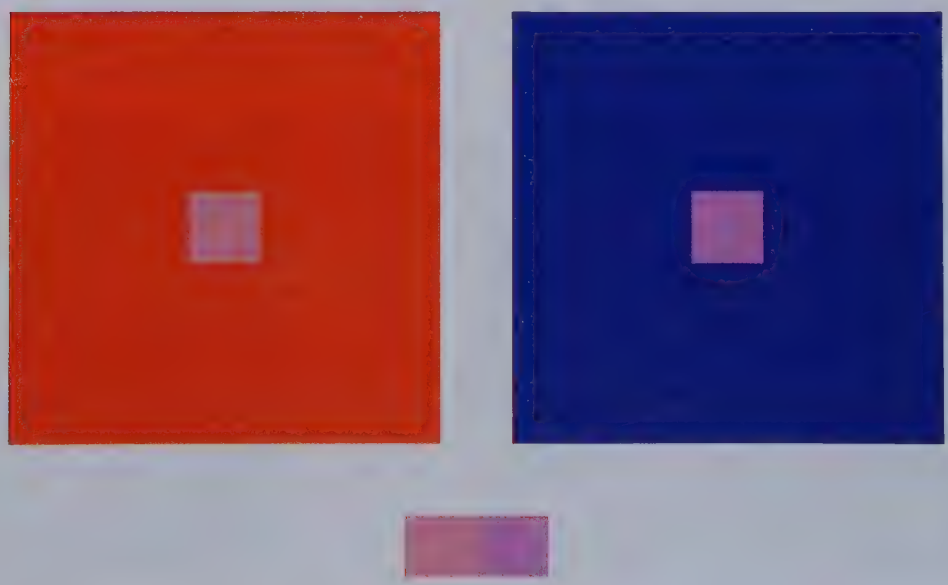


Figure 4–18 Albers's Study. Two colors look like one color. The light, warmer tint of red appears more RV against the orange ground. The darker RV tint appears to be lighter and is pushed toward red by the violet ground.

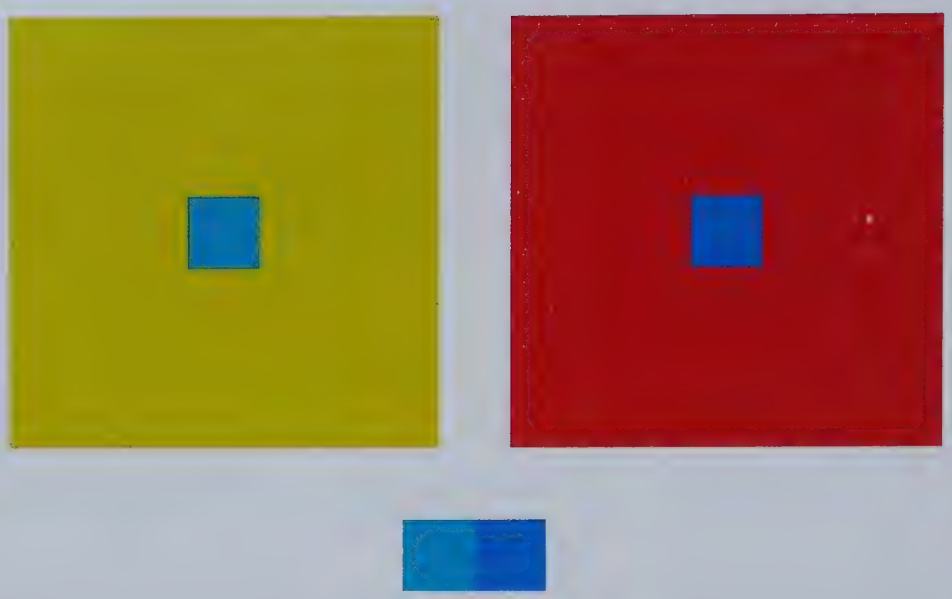


Figure 4–19 The lighter BG looks darker and less green on the YG ground due to subtraction. The blue appears lighter on the dark orange ground and also slightly bluer because of the complementary effect.

For the first example, a light and a darker tint of red (pinks) have been chosen. The goal is to visually equalize these two colors by manipulation of ground colors. [4.18] To make the lighter pink appear darker, it has to be placed on a lighter value ground. To make the darker tint of red appear to be lighter, it has to be placed on a darker value ground. The lighter pink has an RO cast, so it is placed on a full-saturation orange, to subtract some orange and leave it a cooler pink. The darker pink is more RV but can be pushed toward light red by placing it on a darker violet ground to subtract some of the violet element from the red. The dark value of the violet also forces the RV pink to be slightly lighter in value.

Two slightly different hues can also be visually equalized. [4.19] A lighter BG and a slightly darker blue can be made to look the same by careful experimentation. The lighter BG can be placed on a YG ground to make it darker in value and pull some of the green cast out of it by subtraction. The yellow also pushes the BG toward violet, making it seem more like a BV. The darker blue looks lighter and more BG on a dark red ground. This occurs because the red ground brings out any green component in the blue due to complementary reaction.

OPTICAL MIXTURES

Optical mixtures are a type of color interaction that expands upon color relativity by finely interwoven areas of color. In optical mixtures, two or more colors can either oppose or blend with each other. *Optical mixtures* of color employ tiny amounts of two or more colors, which visually blend to create yet another (third) color. Either pigmented materials or light may form an optical mixture. In light, optical mixtures are responsible for the colors that we see on our television screens and computer monitors. In the four-color printing process, subtractive optical mixtures create all the colors. The process primaries, cyan, magenta, yellow, plus black, are printed in tiny dot patterns to mix visually.

The human eye is incapable of signaling rapid fluctuations of light and dark to the brain. Film, for example, has a frequency of forty-eight individual flashes of light per second. Our eye and brain process these flashes as a continuous moving picture. This optical phenomenon is known as the *persistence of vision.* The idea of optical mixture is interrelated with the notion of persistence of vision. An optical mixture is a blend of two or more colors that occurs in the eye and brain and creates a single color sensation. There are two major color theorists who broke ground in the area of optical mixture.

James Clerk Maxwell and Michel Eugene Chevereul, the researcher of simultaneous contrast, both explored optical mixtures. Chevereul discovered that many color mixtures were obtainable from a relatively small number of colored yarns in textile manufacture. He explained that these colors were produced by optical combinations of yarn in the fine thread grid (the warp and weft) of woven fabric.

Color Mixing Discs

Nineteenth-century color theorists' research was directly aimed at helping artists in the practical use of color. To demonstrate visual mixtures, a device was created called an *optical mixing disc*, sometimes called *Maxwell's disc* after James Clerk Maxwell (1831–1879), the Scottish physicist. Maxwell used the mixing discs in his research on the light primaries. Chevereul, Goethe, Ostwald, and Albers also did research with a mixing disc. An optical mixing disc is essentially like a toy top with a pattern of two colors in a stripe configuration. The top is spun to see how the colors "mix." When we see rapidly alternating colors in sequence, the colors appear to be continuous. Due to persistence of vision, the two colors seem to be a single color.

Color discs or tops can be constructed and spun manually or on a drill bit to form optical mixtures. For example, a disc that alternates blue and green will produce a color sensation of cyan when rotated. [4.20] When two colors are optically mixed by movement, the resulting color is an additive rather than a subtractive mixture. For example, when a disc with stripes of blue and green is twirled, we see the additive mixture of cyan rather than the subtractive mixture of BG. [4.21] Theoretically, red and blue should result in magenta; green and blue should make cyan; and red and green should appear yellow when visually mixed by movement. [4.22] In reality, the mixing discs form muted rather than pure versions of these colors. [4.23] Stripes of complementary hues on a cardboard disc or top emulate the experimentation of Nicholas Ogden Rood (1831–1902), an American scientist and artist–color theorist who explored optical mixtures. Rood's experiments with color discs verified the exact complements of hues in artists' pigments, as presented in his book *Modern Chromatics* (1879). He experimented with mixing discs using complementary colors to fabricate grays and to pinpoint exact pigment complementary colors. Optical mixing discs can also produce lower-saturation colors when a color is alternated with gray, black, or white.

Broken Color

The static juxtaposition of two or more colors can also produce the sensation of a third color. This technique is also called broken color. Eugéne Delacroix (1798–1863), the French artist, used color hatching to make new colors from optical mixtures of small

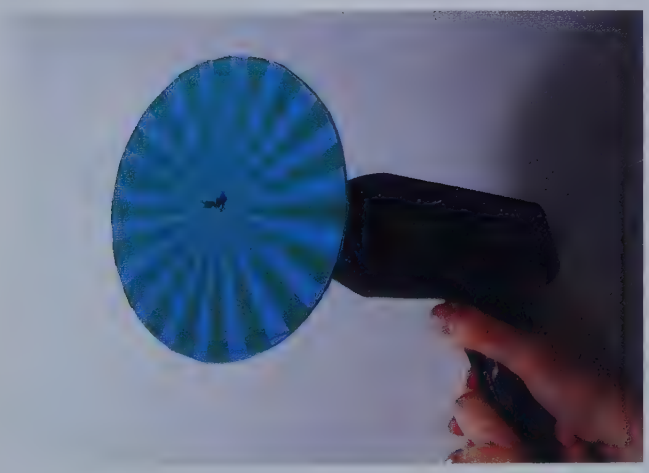


Figure 4–20 A stationary analogous mixing disc. Courtesy of Becky Koenig.

Figure 4–21 Analogous Optical Mixture by Motion. Analogous colors keyed to the same value will visually mix and become lighter because they mix additively when in motion. Courtesy of Becky Koenig.

Figure 4–22 A complementary mixing disc. Courtesy of Becky Koenig.

Figure 4–23 When moving, the mixing disc appears as a red/green chromatic neutral, tinged with yellow, which is the additive mixture of red and green. Courtesy of Becky Koenig.

marks of color. Optical mixtures can produce a type of color atmosphere in a painting. The Impressionists, for example, felt that small marks of color adjacent to each other in a painting would create a more vibrant sense of light than a flat or gradated tone. Broken color was a strategy used by painters throughout history, but most vividly put to use by the Impressionist painters and by a Postimpressionist named Georges Seurat.

Painters today still use some of the strategies of Georges Seurat and the broken color of optical mixtures. The contemporary American artist Chuck Close's (1940–) work evolved from large-scale photorealist portraiture into a grid system that creates a face formed from color marks that define lights, darks, and color tonalities. Each part of this grid operates with a sophisticated method of visual color mixing to create, from a reasonable distance, a real, but fluctuating portrait. The painting shown here [4.24] is a portrait of the artist Kiki Smith. It can be said that Close employs a similar type of *divisionism* developed by Seurat to generate color luminosity in painting. Close's paint marks are much more diverse in shape and scale than Seurat's perfect dots, and his paintings embrace the structure of the grid. The optical mixtures in the painting, for instance, small marks of red and green placed adjacent to each other to make a brown, are a direct link to the history of broken color. A brown made by optical mixture is similar to the chromatic neutral made from a physical mixture of red and green pigments. Optical mixtures seem to blend in a quasi-additive manner, producing the visual sensation of luminosity and heightened color saturation in a painting.

Optical Mixtures of Pigmented Color

An optical mixture of traditional materials such as pigment, inks, or dyes involves the use of tiny dots, dashes, or marks of at least two colors. [4.25] Optical mixtures may create a hue, value, or saturation change depending on what colors are mixed. To understand the concept of optical mixture, the student can formulate simple two-color studies. Each color in these studies should occupy an equal amount of surface area. There are many types of color combinations that readily mix; however, two specific types of optical mixtures illustrate how colors harmonize or contrast.

The first type of optical mixture is called a *sympathetic analogous mixture.* Analogous hues are neighbors on the color circle, causing them to be both sympathetic and harmonious with each other. The color similarity of analogous colors allows ease of visual blending. Theoretically, a wide gap between hues can produce an optical mix, such as blue and red to make violet. In a fine pattern of two colors as in pointillism, the optical mixture imparts an effect similar to a subtractive pigment mixture but with additional luminosity.

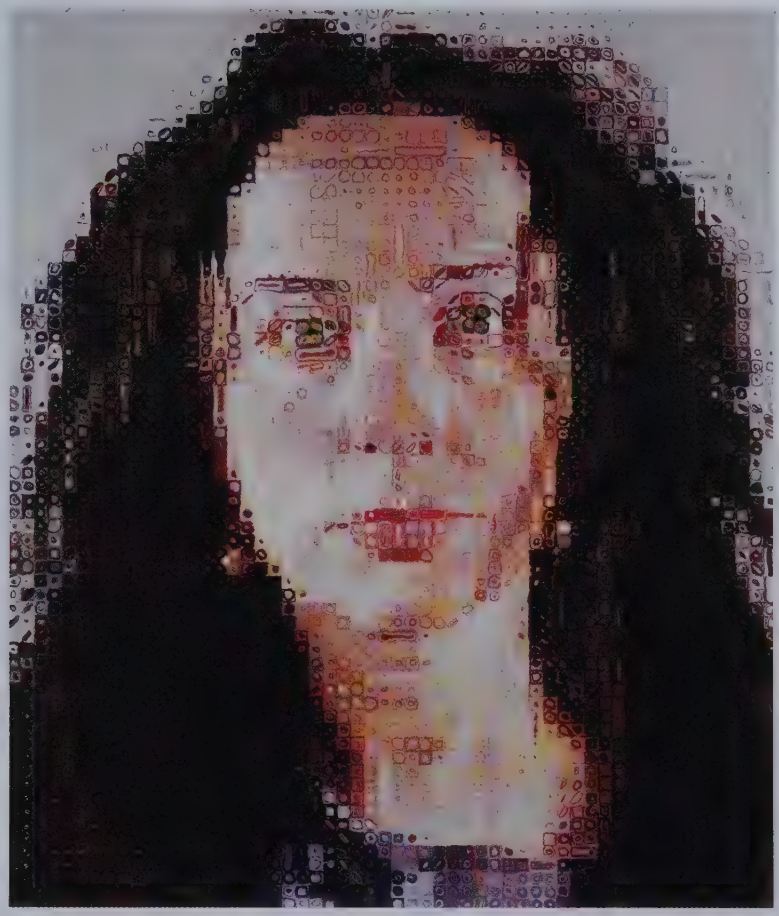


Figure 4–24 *Kiki* (1993), Chuck Close. Oil on canvas, 100″ × 84-1/8″ × 3-3/8″. Collection Walker Art Center, Minneapolis. 1944.7. Gift of Judy and Kenneth Dayton, 1994. The contemporary artist, Chuck Close, uses a grid system for the optical mixtures that build into realist portraiture with small marks of color.

A pair of neighboring hues from the color circle such as YG and green yield a more subtle optical mixture. A fine mosaic made with these hues results in a visually mixed color between YG and green. [4.26] When manually creating a mosaic from colored paper or paint, it is difficult to construct a mesh fine enough to visually blend. The result may become a pattern with too much value contrast. When colors are keyed to the same value level, for example, by lightening the green to the same value level as YG, they generate a more believable visual mix. Contrasting values do not fuse together as readily as value-keyed colors. Colors with matching values readily blend together, seeming to exist within the same spatial plane.

The second type of optical mixture is quite different. This optical mixture is made from opposing or complementary hues. In a very fine pattern, a complementary pair such as yellow and violet will neutralize each other in the same manner as they would in a pigment mixture. However, in a coarser textured mosaic, a phenomenon called *complementary vibration* occurs. Our eye "wants" to see the complementary colors simultaneously for visual balance. However, when we do see the pure complementary hues simultaneously, something unexpected occurs. The complements seem to repel each other, causing an illusion of movement or visual vibration. [4.27] Note that this study is difficult to stare at for any length of time! High-saturation (pure) opposing hues vibrate in the most dramatic fashion. Red and green create one of the strongest complementary vibrations because the hues are close in inherent value.

The painting by Richard Anuszkiewicz takes advantage of the complementary vibration of red and green to create a luminescent effect that emanates from the central square. [4.28]

Figure 4–25 Optical Mixtures of Small Areas of Color. Clockwise, from top left: complementary colors, analogous colors, two hues, and a color and gray.

OTHER TYPES OF COLOR INTERACTION

The Bezold Effect

Wilhelm von Bezold (1837–1907) was a German scientist who attempted to create a color system based on perception. Like Chevereul, he was involved in textile production. In the course of his research, he noted that a single color change within a pattern affected the appearance of all the remaining colors in the pattern. In this type of color interaction, the substitution of a single integral color causes multiple color shifts in a design, a phenomena known as the Bezold effect. Bezold's theories are practical for artists or designers who work with groups of color combinations. The Bezold effect is most prominent in a pattern because compositional forces do not interfere with color perception in simple patterns. Individual colors in Bezold studies change in appearance, and relationships between colors are also affected. Altering the appearance of an entire group of colors is more difficult than modifying a single color in an Albers study. In this example, the contrast between the lower yellow-green shape and the background on the

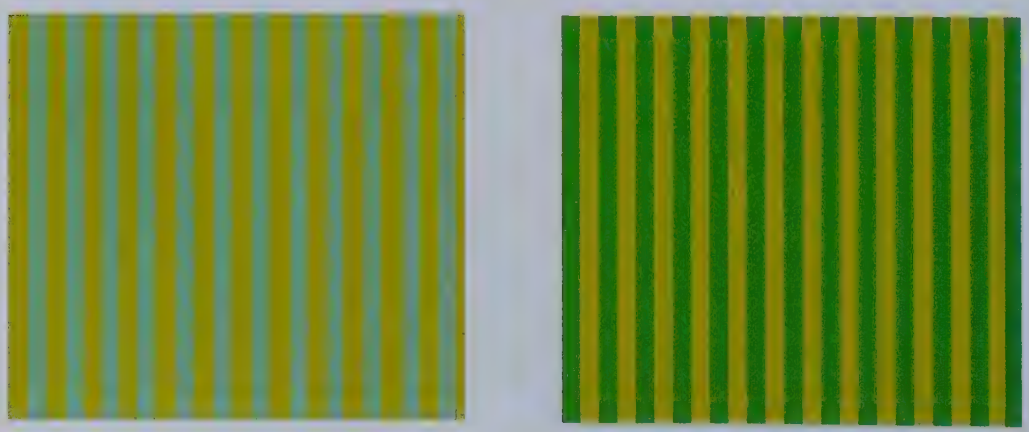


Figure 4–26 If YG and green are to form an analogous optical mixture, they have to be adapted since there is too much value contrast between the hues. Colors that are keyed to the same value level will visually mix more readily; YG and green formulate a color between the two hues.

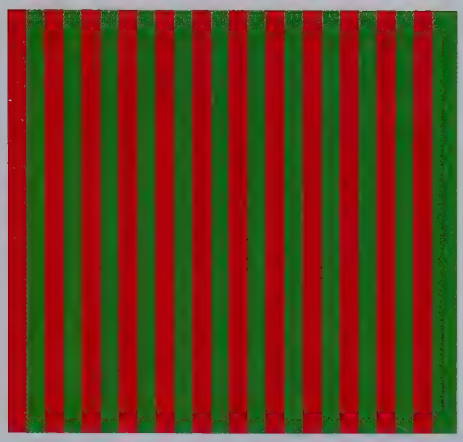


Figure 4–27 A strong complementary vibration is caused by the juxtaposition of pure red and green.

left is pronounced and makes the YG appear much lighter than on the right. [4.29] Colors seem to change in a different manner depending on each relevant principle of color interaction. For instance, the colors in the illustration do not all change equally; the contrast between the central orange and violet shape is more marked on the right than on the left, while the top and bottom small red and orange diamonds have very little visual change.

Figure 4–28 *Iridescence* (1965), Richard Anuszkiewicz. Acrylic on canvas, 60" × 60". Gift of Seymour H. Knox, Jr., 1966. Albright-Knox Art Gallery, Buffalo, New York, NY © Licensed by VAGA, New York, NY/Art Resource, NY. This painting by Richard Anuszkiewicz produces a luminescent effect of complementary vibration through the red and green optical mixture in the central area of the painting.

Figure 4–29 The Bezold Effect. Note that the colors and color relationships appear different due to a a color change in the background.

Color Dominance

The Bezold effect is created by a single color change integral to a pattern. Color dominance occurs when a single hue, value, or saturation is permitted to be preeminent in a composition. A dominant color influences all the colors in a composition by covering the most physical area of a composition. When a dominant color is relocated to another place or given another proportion within a composition, the color dynamics of the entire composition are changed. [4.30] In order to understand color dominance, an identical set of colors is used in identical compositions. The only way to vary the compositions is to manipulate proportions of the same set of colors. Variations of color proportion and location reorganize the compositional forces of visual weight and balance. The same color palette and composition is used for all of the examples shown.

COLOR TRANSPARENCY

Actual Transparency

Actual color transparency is either the perception or use of transparent colored materials. Actual transparent materials are colored glass, filters, acetates, transparent plastic, and other items. [4.31]

Most color perception is a result of either reflection or absorption of various light wavelengths. In our perception of a transparent object, a different phenomenon occurs. A transparent object filters light wavelengths to create a color sensation, which is called *light transmission*. For instance, green glass obstructs both blue and red light wavelengths and transmits only green light.

The only transparent traditional painting material is watercolor. The transparent films of watercolor achieve glasslike effects and a sense of volume on a two-dimensional surface due to layers of paint.

Transparent media produces actual transparency with either watercolor or thinned acrylic paint (using no white). Colored washes or glazes are actually transparent films of color. To demonstrate color transparency, where colored shapes overlap, layers of paint form a visual mixture of the colors involved. For example, yellow glazed over blue produces green. In transparent washes, care must be taken to

Figure 4–30 Color Dominance. One color dominates each composition, showing that the dynamic of a composition can be shifted with the repositioning of color. An identical group of colors is used in varying proportions and positions within each composition.

equalize the wash's color saturation and value. Otherwise, stronger or heavier colors will dominate, reducing color transparency.

Simulated Transparency

Simulated transparency is a type of color interaction that uses opaque media to produce an illusion of transparency. Two opaque colors overlap and seem to "mix" into a third

Figure 4–31 Transparent colored objects transmit a particular color wavelength, blocking other wavelengths. Courtesy of Becky Koenig.

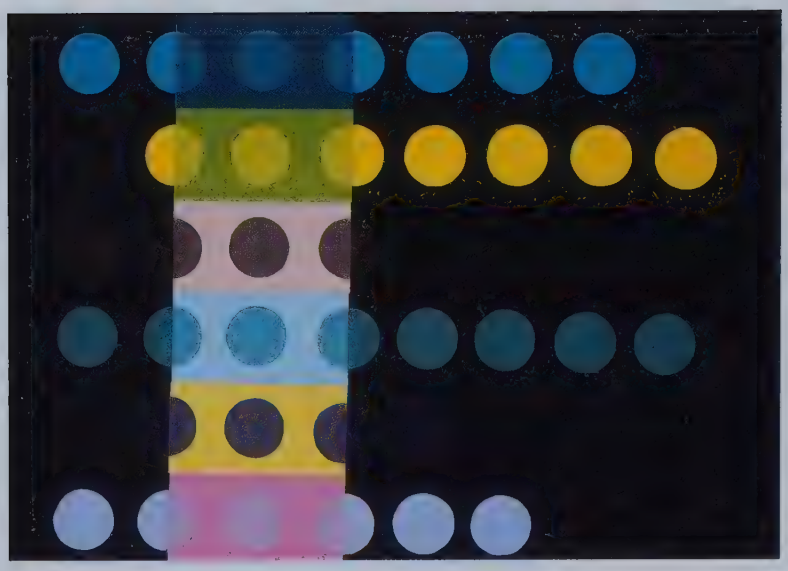


Figure 4–32 Student example by Merrill Stephens of simulated transparencies in a design. © Merrill Rose Stephens.

color (also an opaque color), creating an illusion akin to layers of colored glass or film. Opaque colored paper is the optimal medium to construct a simulated transparency. Colored paper studies help us to visualize "mixtures" between two "parent" colors, instead of manually mixing paints. [4.32]

Any two-color combination can be selected to formulate simulated transparencies. To envision a subtractive color in between two parent colors is a logical process based on the color circle. For instance, the artificial transparency between the hues blue and red is violet. Various violets can be selected to approximate the in-between color mixture. By physically placing the violets in between the parent colors, one color will seem to "click" to form the optimal illusion of transparency. An in-between color that simulates transparency cannot be higher in saturation or darker in value than either of the two parent colors.

Simulated transparencies can also be formed from virtually any color pairing. Some examples shown here are two-value variations of the same hue, complementary colors that form chromatic neutrals, and two different hues that make a third hue. [4.33]

A simulated transparency can also be made with opaque paint by mixing the color between the two parent colors. This process is often difficult because in painting, subtractive color mixtures tend to become darker and less saturated than the parent colors. To alleviate this problem, the in-between colors can be lightened in value.

A related strategy, which creates the illusion of translucency, is called a *consistent value shift*. When the values in a specific area of a design or composition shift as shown, there is an illusion of translucency in the area of the value change. The optimum method of creating this illusion is to shift values by paint mixture or with colored paper. [4.37] The challenge of this exercise is to have the values shift to a lighter or darker range consistently, by choosing colored papers carefully, in a similar fashion to creating a simulated transparency. This can also be accomplished with accurate paint mixtures.

Color is a relative visual sensation. This makes it subject to change based on lighting, color environment, surrounding colors, optical mixtures, and transparency. The study of color relationships sensitizes us to the interaction of color.

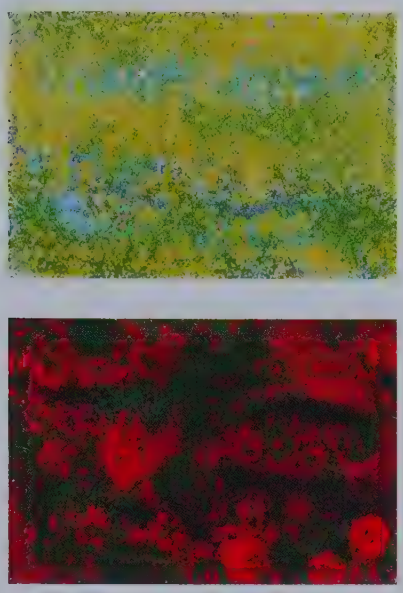


Figure 4–33 Optical Field Mixture. An informal field or pattern of color also creates a color atmosphere or texture that is also an optical mixture.

Activities

1. Color Interaction Studies

Objective: For the student to understand that color perception is influenced by surrounding colors. The following are classic Albers studies of color interaction.

Media: Colored paper.

A. Make one color look like two colors.

- Using the concepts in this chapter, take one color and place it on two different grounds to make it appear to be two different colors.
- The proportion should be approximately 6″ × 6″ or 5″ × 5″ square for the ground and a 1″ × 1″ square or a 1/4″ stripe for the color to be changed.
- The point is to make the same color look radically different by manipulation of various colored grounds. Try many possibilities with colored paper until you get a major color change.
- Remember to make the grounds as different as possible. Differences in hues (opposite hues), saturation, color temperature, and/or value are needed to truly change the color you have chosen.
- When the color interaction is complete, cite the principles used that implemented your color change. [4.12, 4.15]

B. Make two different colors appear to be the same color.

- This study is invariably more difficult than the first study.
- Pick two slightly different colors from colored paper.
- The colors may vary in value, for example, a lighter and a darker orange. They also can be slightly different in hue, a green BG and a bluer BG, for example. The two colors might be slightly varied saturations of one color, for example, blue and a tone of blue.
- Now pick two different grounds to try to equalize the two colors that you have chosen.
- Try to use the three principles of color interaction to implement this. Example: If you are using a lighter and darker value of one color, you can put the light color on a light ground and the dark value on a dark ground. Also use subtraction and/or complementary reaction if necessary.
- Save an extra piece of each color used and place it as shown with your study. This will indicate where each color is placed and indicate the color differences. [4.18, 4.19]

2. Optical Mixing Studies

Objective: The student will create two optical mixtures, one that makes two colors blend visually and one to create complementary vibration. Physical movement can be used to create additive color mixtures.

Media: Colored paper.

A. Analogous Optical Mixture

- Pick a pair of analogous or almost analogous hues (by skipping the in-between hue) from the color circle. Example: Blue and BG or red and violet.
- The colors should be keyed to the same value as closely as possible. The value match will create a better optical mixture.
- Make a pattern or fine mosaic of stripes, dots, a grid, or any pattern using equal surface area for each of the two colors. This will let them blend visually when viewed from a reasonable distance.
- The result will be two colors that blend optically to create a third color that is in between the two. Example: yellow + orange = YO or yellow + YO = YYO. [4.34]

B. Complementary Vibration

- This visual mixture is the opposite of an analogous mixture.
- Pick any dyad or complementary pair from colored paper.
- Make sure that the colors of the dyad are high in saturation, as shown.
- Create a similar or the same pattern mesh as in Exercise 2A.
- You should notice a strong movement or vibration as you look at this study.
- If you view it from across the room, you will notice a change in contrast and possibly a neutral color. [4.27]

C. Optical Mixture Discs

- Make several optical mixing discs to show additive color mixtures.
- The discs should be circular, either glued or painted on a toy top or made of a flat cardboard disc to be spun on an electric drill.

Figure 4–34 Simulated transparencies made with opaque, colored paper. The correct choice of an in-between color must be chosen from the two parent colors. Simulated mixtures clockwise from the top include two value levels of one hue, hue-to-hue mixtures, two analogous hues, and complements that mix to form a chromatic neutral. Courtesy of Becky Koenig.

- You can use two analogous hues, complementary hues, or black and white. Glue or paint the two colors in an alternating stripe pattern, or make them on the computer and print out and adhere onto heavy paper or light board.
- What color sensations do you get when the discs are revolved? How are the results different from what you would expect?

D. Additional Optical Mixtures Activities

- Optical Field mixtures: In a much more casual manner, create optical mixtures with broken colors in paint. Using dots, marks, or small lines, create fields of color created from two or three analogous colors that are keyed to a similar value, such as light green, light BG, and light B. These can be created with paint or with pastel or colored pencil.
- Complementary Optical field mixtures can be made from complementary pairs such as BG to RO, in very small marks of paint, colored pencil, or pastel (these drawing materials can also be used along with the painted surfaces). These studies should change in appearance depending on how close the viewer is to the piece. [4.33]

3. Bezold Effect Studies

Objective: These studies are meant to explore the concept of the Bezold effect, multiple color interactions, and color dominance.

Media: Colored paper, paint, or a graphic program on a computer.

A. Bezold Effect

- Plan a simple geometric pattern that uses four or more colors.
- Choose two different grounds for your studies that substantially change the appearance of all the colors in the study. Try to choose grounds that are opposing light and dark values, complementary hues, or colors that are high and low in saturation.
- The design should appear to be very different chromatically from one ground to another.
- Make sure to let the colors in each design interlock so that the change in interaction between them can also be noted. [4.29, 6.19]

See Chapter 6 Activities for a version of this study on computer.

B. Color Dominance Studies

- Pick five or more colors to create two or four studies. Create a simple design or pattern.
- Make two studies using the same color selection and the same design.
- Each study should have one color (from your chosen group) that dominates the whole study. You can also change the location, proportion, or repetition of colors from one study to the next.
- The point is to radically change the appearance of the same design and color grouping by the location and proportion of the colors. [4.30]

4. Transparency Studies

Objective: The student will work with both actual transparencies (transparent media) and simulated transparencies (opaque media) to understand the differences between the two concepts.

Media: Colored paper, watercolor, or acrylic paint.

A. Actual Transparency Study

- Choose at least four hues or pigment colors with which to work.
- Make a simple overlapping design of geometric shapes or brush strokes on cold press illustration board or watercolor paper. Draw design out in pencil.
- Try to have some areas where at least three shapes overlap.
- Use either watercolor or acrylic paint (watered down and without white) to create washes of each of your chosen colors.

Figure 4–35 Actual Transparency Study. Transparent color media can be used to create a study that is made from washes of overlapping color.

- Make sure all of your colored washes are of approximately equal intensity.
- Carefully fill each shape of your design with the washes. Make sure that you let each layer dry before washing over with another color. Layer color carefully to create transparencies.
- As desired, you may leave the background white or paint it black. [4.35]

See Chapter 6 Activities for a digital version of a similar study.

B. Simulated Transparency Study

- From colored paper, choose at least four pairs of colors that you want to overlap in a design. Make sure each pair is a different type of color combination.
- Design a simple overlapping structure using geometric or freehand shapes.

Figure 4–36 Student example of a simulated transparency study by Kristen Walkowiak. © Kristin Walkowiak.

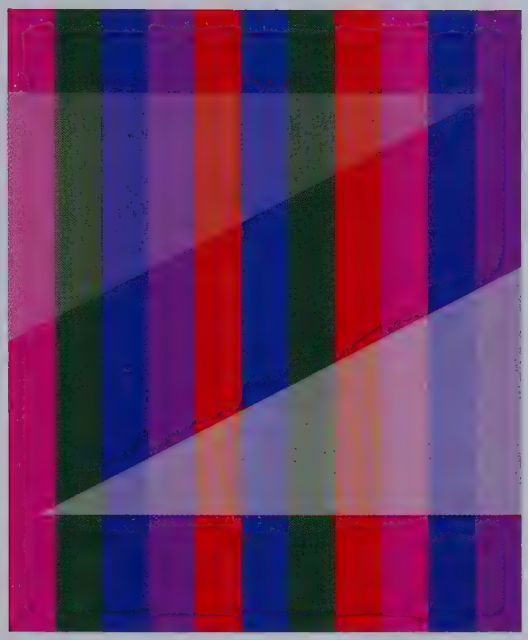


Figure 4–37 Consistent Value Shift Study. An example of a consistent value shift.

- Pick colors that represent the in-between or offspring color between all four sets of parent colors that you have chosen.
- Where the components of your design overlap [4.34], place the appropriate colors to simulate the illusion of transparency.
- The negative or ground color should be dark or neutral to accentuate the illusion of transparency. [4.36]

C. Consistent Value Shift

- In a flat composition of organic or created shapes, make one or two shapes that are an to overlay the others. Inside this overlaid shape, the color values of everything inside will shift consistently lighter or darker based upon the shape contained underneath. This will give a feeling of a transluscent shade or scrim that affects all the colors behind it. Choose or mix colors to make them lighter or darker visually, consistent with values of the original colors. [4.37]
- Can be made with colored paper or paint. This study can be made on the computer, but it is not as worthwhile as an exercise because the color changes can be made with a transparent white or gray, using the transparency percentage slider, rather than choosing or making colors visually, which is preferable.

Glossary

Actual color transparency The perception or use of transparent materials. When we perceive a transparent object, the light is transmitted; that is, it is allowed to go through the object to create a color sensation.

Bezold effect The effect of changing the dominant color in a given design and the subsequent varying of all the other colors.

Color interaction A color illusion that occurs in our perception of color due to the interconnected relationships of colors. Also called relative color.

Complementary vibration Complementary vibration occurs when two full-saturation complementary hues are in close proximity. When these conditions exist, the colors will generate the illusion of movement.

Optical mixtures Colors that use tiny amounts of two or more colors that visually blend to create another color. An optical mixture can visually combine either pigmented materials or light.

Simultaneous contrast Refers to colors that interact and affect each other, which can give them a different or varied appearance. Also refers to when the eye simultaneously "wants" to see the complement of any given hue, affecting our perception of color in relationships.

Simulated transparency A color illusion in which opaque media is used to create an illusion of transparency.

Successive contrast A spontaneous color image produced in direct succession to the eye's overexposure to a single full-saturation color, also called *afterimage.*

Chapter 5

The Materials of Color

LEARNING OBJECTIVES

- To understand physical color materials in contrast to process color, the difference between analog (direct) and digital (indirect) media processes.
- An explanation of colorants, both pigments and dyes, and their uses in physical and digital media applications.
- A historical overview of types of painting, pigments, and binders in detail.
- The relationship of color theory, RGB, to color photography and commercial color separation.
- The relationship of the process primaries, CMYK, to commercial printing.

INTRODUCTION

Artists and designers have a wide assortment of colored materials at their disposal to create color harmony, expression, and design. Colored media consists of physical materials like pigments and dyes, printing processes, and digital media made from light itself. *Physical color materials* are those used directly; we may refer to these as *analog media*, such as paints, colored drawing materials, traditional printmaking, and textile dyes. *Process media* is used indirectly and is primarily *digital media*: commercial printing, photography, and digital electronic media.

PHYSICAL COLOR MATERIALS

Physically colored materials are known as colorants. A *colorant* is a compound that imparts its color to another material. The word *colorant* has multiple definitions. A colorant may be formulated from the color component of a natural object, such as a plant. It also may be the colored ingredient of a mixture, like the pigment in paint. A colorant is also known as an agent that lends its color to another substance, like a fabric dye.

Pigmented Materials

Pigment is the oldest form of colored art material used by man. Cave paintings were created from assorted earth pigments. A *pigment* is defined as a colored powder that, when distributed over a surface in a layer, transmits its color effect to that surface. A pigment is a chemical substance capable of reflecting a particular light wavelength, which, in turn, generates a specific color sensation. Pigments are finely ground insoluble powders that become paint, pigments by mixture with a binder, also known as a *vehicle*. [5.1] Without a binder, a pigment cannot adhere to a surface but simply dusts off as a powder. When pigment is ground into or mixed with a binder, it does not dissolve but instead forms a liquid/solid suspension. Pigment powders are made consistently of the same chemical substances regardless of the type of painting or drawing media. For example, Ultramarine Blue pigment is always the same chemical composition, whether it is formulated into tempera, oil, acrylic, or watercolor paint. [5.2] Each painting media is characterized by its binder, which influences the paint quality, handling, and color appearance of each pigment. The surface or *support* (such as canvas) to which paint is applied also influences each painting media's individual personality and distinct qualities.

Most artists' pigments are colorfast. *Colorfastness* is the resistance of a color to the loss of its original color quality, which means that it will not darken, fade, bleed, or wash out over time. Artist's colors generally have high colorfastness ratings, although there are a number of colors that are somewhat less permanent.

Pigments do not adversely react with vehicles or binders because they are chemically inert. There are variable opacity or transparency levels of each individual pigment.

Figure 5–1 A pigment is a colored powder that is mixed with a binder to make paint. Shown here are an earth pigment and Titanium White pigment. Courtesy of Becky Koenig.

Although the same pigments are used for various painting media, some are more suited to a particular medium. For example, transparent pigments (such as Ultramarine Blue) are especially applicable for watercolor, a transparent painting medium. Opaque pigments (such as cadmiums) are particularly appropriate to oils, an opaque painting medium.

Types of Pigment

There are two categories of pigment, organic and inorganic, which are further divided as follows:

Inorganic

Earths—Ochres, Umbers
Calcined Earths—Burnt Umber, Burnt Sienna
Artificial Mineral Colors—Cadmiums, Zinc Oxide

Organic

Vegetable—Gamboge, Indigo, Madder
Animal—Cochineal, Indian Yellow
Synthetic Organic—Phthalos, Alizarin, Azo, Hansa, Quinacridone

Before the nineteenth century, most coloring agents were derived from natural sources. Many of these sources were difficult to obtain or time consuming to process. Bright colors such as blues, reds, and yellows were more expensive or unavailable. The plentiful and inexpensive pigments were the earth colors. Earths are native clays (inorganic) with high metal content such as red ochre, iron oxides, siennas, umbers, ochres, and green earth. Inorganic minerals were rarer, as they were ground natural ores, such as cinnabar, malachite (green), azurite (blue), and ultramarine (lapis lazuli), which were essentially finely ground colored stones. Most surprising to today's artists

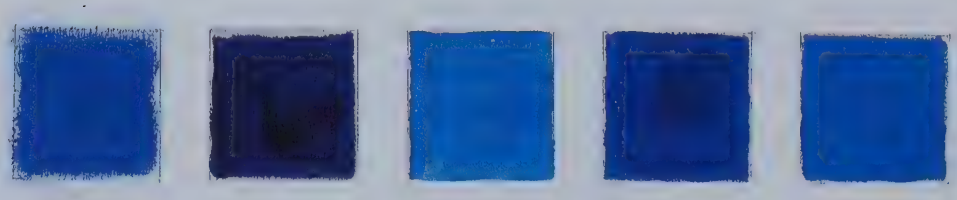


Figure 5–2 The same pigment, Ultramarine Blue, is shown here in different binders. From the left: pastel, oil, watercolor, acrylic, and gouache. Notice the differences in color and surface. Courtesy of Becky Koenig.

are the contents of the pigment compounds made from animals. Examples of these are sepia (ink of cuttlefish), crimson (dried lice), carmine (cochineal insects), and Indian yellow (cow urine). Other organic sources included plants, roots, berries, flower heads, barks, and leaves. Examples include the root of the madder plant to make rose madder, a red; chamomile flowers for yellow; iris or ragweed for green; and an Indian plant, indigo, for blue.

In the nineteenth century, pigments and dyes began to be chemically produced. Often, these pigments were actually dyes fixed to inert inorganic pigments such as the red and orange lake pigments. Synthetic organic pigments that are still in use today are phthalos (greens and blues), azos (yellows, reds, and oranges), and quinacridones (reds and violets), along with many more. The change from natural pigments with organic sources occurred because the organic synthetics are more permanent and intense colors. Inorganic pigments are still used today, in particular, the earth colors and artificial mineral colors such as the cadmiums. The number of pigment colors available today would overwhelm the artist of the Middle Ages or Renaissance.

Hues from the color circle do not always correlate with a single pigmented color. Often there are several pigment color choices for each hue; for example, a blue-green may be Cerulean Blue, Manganese Blue, or Phthalo Blue. A chart of pigment equivalents to the traditional twelve hues from the color circle are outlined in Table 5.1, along with the chemical content of each pigment.

Vehicles and Binders

The definition of a *vehicle* or *binder* is a substance that holds and binds pigment particles together. A binder also assists in the ease of pigment application to a surface. A vehicle must dry to a durable film that both suspends the pigment and binds it to a surface support. A *support* is an appropriate surface to which each paint medium is applied, whether paper, wood, or canvas. All vehicles or binders have a measure of *plasticity*, that is, to allow paint to flow and/or be paintable onto a surface. The consistency of binders ranges from a thin liquid to a thick paste. Binders include an array of substances: fats, oils, gums, waxes, resins, and polymers. [5.3] Each type of vehicle triggers pigments to react in a particular way when light is absorbed or reflected from the painted surface. Pigments generally darken when mixed with a binder because a pigment's refractive index (how much light refracts or bends when in contact with the surface) is lowered by the addition of a binder. Each pigment has a reflective surface quality dependent on the type of particles involved. Since pigments are derived from widespread sources, occasionally a binder will cause a pigment to become more opaque or transparent. [5.4] The color quality of a pigment is affected by the following factors: the nature or type of vehicle used, the gloss or matte quality of the paint surface, the type of light upon the colored surface, the interaction of colored areas, the transparency or opacity of the medium, and the type of paint application.

Figure 5–3 Vehicles bind a pigment to the surface support. Clockwise from top left: linseed oil for oil paint, gum arabic for gouache and watercolor, acrylic polymer for acrylic paint, and beeswax for encaustic. Courtesy of Becky Koenig.

Table 5.1

Chart of Hues and Pigments

Hue Name	Pigment Name	Pigment Characteristics	Pigment Source
Yellow	Cadmium Yellow Medium	Opaque, warm yellow	Cadmium Yellow
	Hansa Yellow Light	Transparent, cool yellow	Arylide Yellow and Zinc White
YO	Cadmium Yellow Deep	Opaque, very warm yellow	Cadmium Yellow
		Semitransparent, YYO	Deep
Orange	Cadmium Orange Hue		Arylide Yellow and Perinone Orange
	Cadmium Orange	Pure orange, opaque	Cadmium Orange
RO	Cadmium Red Light	Opaque, warm red	Cadmium Red Light
	Napthol Red Light	Semiopaque	Napthol Red and Zinc White
Red	Cadmium Red Medium	Opaque, somewhat warm	Cadmium Red Light
	Permanent Red	Semiopaque	Napthol Red and Arylide Yellow
RV	Quinacridone Red	Transparent, cool red	Quinacridone Red
	Alizarin Crimson	Transparent, warm RV	Alizarin Crimson
	Cobalt Violet	Transparent, cool RV	Cobalt Violet
Violet	Dioxazine Purple	Semiopaque	Dioxazine Purple
	Permanent Violet	Semitransparent	Ultramarine Violet and Dioxazine Purple
	Manganese Violet	Transparent, slightly BV	Manganese Violet
BV	Ultramarine Violet	Transparent	Ultramarine Violet
	Ultramarine Blue	Transparent, cool blue	Ultramarine Blue
Blue	Cobalt Blue	Semiopaque, cool	Cobalt Blue
	Brilliant Blue	Semitransparent	Phthalo Blue and Ultramarine Blue
BG	Phthalo Blue	Semitransparent, intense	Phthalo Blue
		Green shade (warm)	
		Red shade (cool)	
	Cerulean Blue	Opaque, warm blue	Cerulean Blue, Chromium
Green	Cobalt Green	Semiopaque	Cobalt Green
	Cobalt Turquoise	Semiopaque	Light Green Oxide
	Permanent Green Light	Opaque	Phthalo Green and Arylide Yellow
	Phthalo Green	Transparent, cool, intense Cool	Phthalo Green
	Viridian Green	Transparent, cool	Viridian
	Cadmium Barium Green Light	Opaque	Cadmium Barium Yellow and Phthalo Green
YG	Yellow Green	Semiopaque	Phthalo Green, Arylide Yellow, and Zinc White

The other factors in pigmented color are the coolness or warmness of each pigment, which are indicated in the table above. When colors are tinted, in addition to becoming lighter, they also tend to be made somewhat cooler in color temperature.

Figure 5–4 Notice the color differences between Cerulean Blue dry pigment (on left) and Cerulean pigment in a binder, shown here in oil paint. Courtesy of Becky Koenig.

Opaque and Transparent Media

Opaque paint is sometimes referred to as "body color" because it completely covers the surface onto which it is painted. No light filters through a paint film that is opaque; rathers, the colors are made visible through the absorption and reflection of light. Opaque color can also be thinned and used in a transparent or translucent manner. The *undertone* of an opaque color is the appearance of a color when it is used either in a transparent manner (thinned out) or tinted (by adding white). [5.5]

In transparent media, light passes through the paint layers to the support below. Watercolor, oil glazes, markers, dyes, and some inks are transparent. Light-value colors in transparent media are attained without white tinting mixtures as the white support shows through a thin film of color. The effect of transparent colors is due to the transmission and reflection of light. [5.9]

Colorfastness of Artist's Materials

The permanence of colored materials is of concern to artists and designers. We tend to assume that all materials sold by the art retailer or the inks printed from our computer are permanent. This is certainly not always the case. It can be reliably said, however, that most pigmented materials are tested for lightfastness and permanence ratings. Sometimes

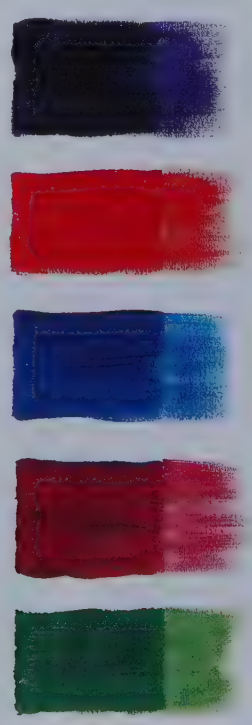


Figure 5–5 Body color in opaque paint is the color seen when the paint is applied heavily and used as a mass. Undertone is the color seen when the paint is applied thinly or tinted with white. Shown here from top: Dioxizine Purple, Cadmium Red Light, Phthalo Blue, Alizarin Crimson, and Permanent Green Light. Courtesy of Becky Koenig.

a paint manufacturer will have the color's permanence rating listed on the paint container. U.S. paint manufacturers are required to supply permanence information, but since many brands of paint are imported, the ratings may often be found on color charts, in product catalogs, or on the manufacturer's website. Permanence ratings are valid only if art materials are properly used. Pastels used on Mylar or oil paint on glass may present problems that the manufacturer could not anticipate. In the United States, toxicity ratings and the exact pigment content of each color must be listed on the packaging of artists' colors. Often the paint's opacity and tinting strength are also included on the labeling. It is best to purchase paints that list the true pigment components of each color on the container.

All artists' pigments are rated for lightfastness. Artists' pigments are held to a much higher standard than, for instance, commercial interior or exterior paint. Lightfastness tests are performed on full-strength pigments and also tints of each pigment. The pigments are exposed to approximately 600 hours of sunlight and then checked for fading. Lightfastness ratings range from I to V, I being the highest rating. Paints are also checked for tinting strength, opacity, and toxicity and sometimes for drying rate, consistency, and paint composition.

Student- and Professional-Grade Colors

When shopping for art materials, we are confronted with a dizzying number of options, particularly when purchasing paint. There are usually two or more quality grades of paint, which may not be apparent to the student or novice reading the label. Student-grade paints have a slightly lower quality level than artist-grade paints and are just as permanent as artist-grade paints, but there are some key differences. Student colors are lower in cost, contain somewhat less pigment, use alternate pigments, and have a more limited color selection than artist-grade paints. In student paints, there can be pigment substitutions labeled as "hues." [5.6] For example, a tube labeled "cadmium yellow hue" indicates that the pigment content is not true cadmium but a substitute pigment, such as Hansa Yellow mixed with a little white to give it the appearance of true cadmium yellow. A cadmium yellow hue may handle and mix with other colors differently than true

Figure 5–6 Student- versus Artist-Grade Color. Notice the difference between true Cadmium Yellow Light, artist grade (top right), and Cadmium Light Hue, student grade (top left). Notice also real Cerulean Blue, artist grade (bottom right) and the student grade (bottom left). All the colors are permanent, but the student-grade paints use alternate pigments. Courtesy of Becky Koenig.

Cadmium Yellow, but otherwise it is a safe, permanent color. Note that student-grade paint does not include children's art supplies, which are meant for fun and not tested for permanence.

Painting Media

ENCAUSTIC One of the earliest forms of painting media is encaustic. Encaustic is pigment mixed with melted beeswax and resin. The colors must be warmed (melted) to be applied. A process called "burning in," when the paint surface is smoothed with a hot metal implement, is used to finish off the paint surface. Encaustic and waxed-based painting methods were used in Egyptian and Roman funerary portraits with lifelike effects that demonstrate the skill of the artists and the resilience of this painting medium. Some contemporary artists use this ancient medium, which is characterized by high-luminosity colors and a matte, satiny finish. [5.7]

FRESCO Fresco painting is a method of mural or wall painting in which the pigment binds with the plaster support. The fresco technique is unique in that there is an absence of a traditional binding agent. Pigments are ground in water and then applied onto wet lime plaster. The plaster must be wet or damp for the binding properties to function correctly, which gives the artist a limited time to work. As the plaster dries, the pigment penetrates into its surface, cementing itself to the lime. In the secco fresco technique, some specific colors, such as Azurite Blue, can be painted onto dry plaster. The fresco technique has been used from Minoan times (2300–1100 B.C.), most notably seen at the palace of Knossos in northern Crete and in Asia, where frescos also adorn the interior walls of Buddhist temples. The fresco technique was a dominant medium throughout the Renaissance. [12.2] Artists employing fresco were limited to mainly earth and mineral colors,

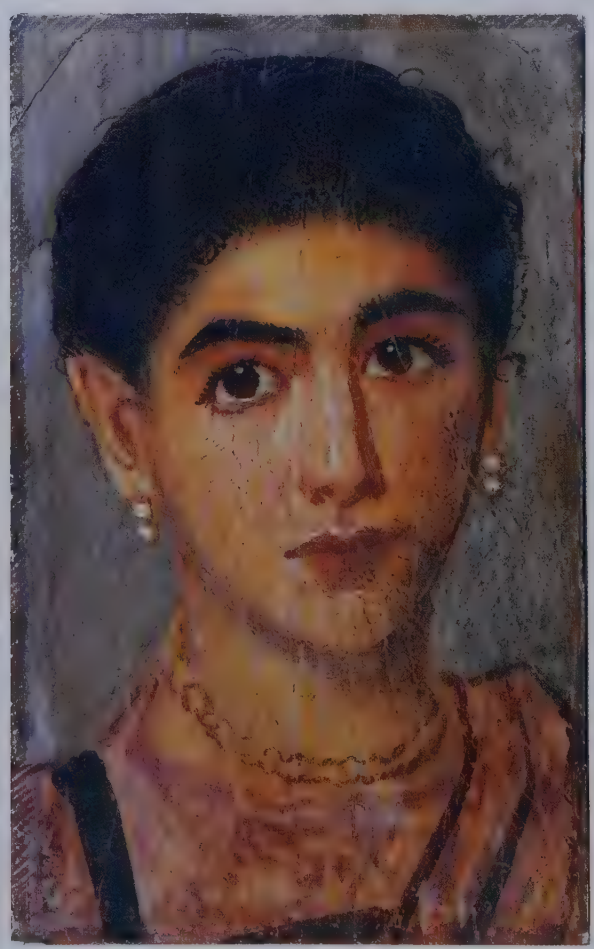


Figure 5–7 *Funerary Portrait of a Young Woman* (161–180 C.E.) Encaustic on wood. Fayum, Egypt, Roman Period. Louvre, Paris, France. Photo Credit: Réunion des Musées Nationaux/Art Resource, New York. This funerary portrait (on the outside of a sarcophagus) by an unknown artist in Egypt during its Roman period is painted in encaustic, the color unfaded by time because of the purity of the medium, which is pigment in a wax binder.

because plant-derived pigments reacted badly with the alkaline plaster. The dried colors of a fresco painting are somewhat pale in value due to the pigment's reaction with lime.

EGG TEMPERA Egg tempera was another early Renaissance technique. In egg tempera, pigments are first ground in water then "tempered" with egg yolk, which serves as its binder. Egg yolk is a perfect natural binder, being an emulsion of water, a nondrying oil, and lecithin. The oil in egg yolk binds the pigment to a primed wood panel support. The yellow of the egg yolk bleaches and thus does not affect the colors of the pigments. The gesso ground (primer) is a mixture of chalk whiting and sizing, which has a bright white, absorbent surface. As egg tempera dries, the water in the emulsion is replaced by air. This causes more light to be reflected from the bright white gesso surface, lending the paintings a special luminosity of color. The proteins in the egg also harden to create a satiny, durable surface. The disadvantage of this medium is the necessity to continually remix fresh paint with fresh egg and the time-consuming application technique, which employs multiple paint layers. Egg tempera was a primary painting medium of the early Renaissance before the development of oil. Although it is not widely used today, several contemporary artists favor it as their primary medium. [5.8]

OIL Oil painting was a direct offshoot of egg tempera painting. Early Renaissance artists began to add small amounts of drying oils to the egg yolk binder for more painting flexibility. Oil was also used as a final varnish over egg tempera paintings. Soon artists discovered that pigments could be ground solely into oil to make a new type of a more flexible paint. The principal type of oil used for oil paint is linseed oil, a natural drying oil extracted from the seed of the flax plant. Oil paint is soluble in gum spirits of turpentine or mineral spirits. The dried oil film serves as a vehicle for the pigment, protecting the particles and binding it to a gesso surface. Other oils, such as walnut oil, poppyseed oil, lavender oil, and hempseed oil, have been used in the manufacture of oil paints and oil medium (a paint additive).

The artist who is commonly credited with the development of oil painting technique is Jan Van Eyck (1390–1441), a Flemish artist, who made major contributions to Northern Renaissance painting. The advantages of oil paint are numerous. Oils have an ease of manipulation due to their slow drying time. Many paint consistencies can be manipulated with oil, from thin glazes to heavy impasto. Oil can be painted on primed canvas, a light, movable support, as well as on a wood gesso panel. In most painting media, the colors change in value from wet to dry, but oil colors retain a similar appearance

Figure 5–8 Catherine Catanzaro Koenig, *Japanese Lanterns,* 2001. Egg tempera on panel. Collection of Becky Koenig. © Catherine C. Koenig 2001. Egg tempera is characterized by a pale value key and translucency, as shown in this work.

from wet to dry. Oil colors also have an innate richness. Some of the disadvantages of oil are the slow drying time and the need for harsh, toxic solvents. The handling and surface quality of oil paint can be enhanced or changed with the additions of varying types of oils, resins, and waxes.

WATERCOLOR Watercolor is the only truly transparent painting medium, making it unique in the list of primarily opaque painting materials. Watercolor came into common use in Western art in the nineteenth century, popularized in England. Optimal pigments for watercolor are those that are transparent by nature, such as Ultramarine Blue and Alizarin Crimson. However, even pigments with characteristic opacity are used for watercolor, such as the cadmium pigments. The watercolor pigments are ground very finely in a gum arabic (glue) solution. Watercolor is available in both tubes or in color pan sets. The proper support for watercolor is watercolor paper, which is lightly sized with gelatin to prevent washes from absorbing into the surface too quickly. Pale value tints are made with thin layers: washes of color diluted with water that allow the white of the paper to show through. [5.9] Watercolor actually stains the surface of the paper as it dries. Since pigments are adhered to the paper surface with a delicate binder, watercolors are matted and protected by glass when professionally presented. This keeps the paint surface clean and protects it from the ultraviolet rays of daylight. Watercolor is a popular painting medium because it is highly transportable, uses water as a solvent, and cleans up quickly. Although watercolor is a medium associated with beginners and children, in reality, working with watercolor is quite complex, requiring both a delicate touch and knowledge of color transparency. Inexpensive children's pan sets of watercolors should be avoided by artists and designers, as they are low in quality and impermanent. Fine brushes and paper are also extremely important for success in watercolor.

GOUACHE Gouache, or tempera, is an opaque form of watercolor. Gouache has a gum arabic as a binder like watercolor, but it also has a larger ratio of binder to pigment than found in ordinary watercolor. The paint is also applied more heavily and with less water than watercolor. [5.10] Watercolor paper or illustration board serves as a painting support for gouache. The addition of various amounts of chalk or white to the pigments give gouache both body and opacity. Gouache is more intense in color than watercolor since it is opaque and contains more pigment. Tempera painting was used for book illumination in the Middle Ages, for Persian miniatures, and for Asian painting on paper and silk. Gouache is commonly used today for fine art or as designer's color. A lower grade of gouache is called poster paint.

ACRYLIC Two Americans, Leonard Bocour and Sam Golden, developed acrylic paint in the 1940s, but this paint did not come into common use until the 1960s. Acrylics are an emulsion of water, pigment, and a polymer resin. The water component of the emulsion allows the paint to be water soluble, one of its main advantages. When acrylic dries, the water evaporates, leaving an extremely strong polymer film that binds the pigment into the paint film and onto the painting support.

Acrylic paint has many advantages; it can be thinned with water, thus eliminating the need for solvents. It can be applied in an opaque, transparent, or translucent fashion, and fluctuates in application from impasto to watercolor-like washes. [5.11] Acrylic paint dries quickly, allowing overpainting almost immediately. It can be painted onto many surfaces, primed or unprimed, including canvas, paper, board, wood panel, and

Figure 5–9 Transparent watercolor washes allow the white paper surface to show through the paint film to create tints. Courtesy of Becky Koenig.

Figure 5–10 A comparison of the transparency of watercolor (top) to the opacity of gouache (bottom). Courtesy of Becky Koenig.

Figure 5–11 Acrylic is the first paint using a synthetic binder, polymer resin. A versatile medium, acrylic is capable of a wide variety of effects. Clockwise from top left: a tint, body color, a transparent wash, and a texture made with acrylic gel, all with Dioxizine Purple pigment. Courtesy of Becky Koenig.

plastics. Additives for acrylic paint can produce numerous paint surfaces: gloss and matte mediums, gels, and modeling pastes. The disadvantages of acrylics are changes in color and paint quality that occur when the paint dries. Acrylic dries too quickly for some artists, not allowing enough time for paint manipulation.

DRY COLOR-DRAWING MEDIA There is a wide selection of dry color-drawing materials, including colored pencils, chalk pastels, pastel pencils, oil pastels, oil sticks, and wax crayons. Color-drawing media are all suitable for a paper surface as a support. [5.12]

Colored pencils are colored sticks in wood casings. They are made from pigments mixed with clay, a synthetic resin, and wax. They are also available in a water-soluble composition and are called watercolor pencils. The lightfastness of colored pencils is questionable, since some pencils have dyes rather than permanent pigments, so artist-grade colored pencils should be used for finished fine art or illustration. Colored pencils can be translucent or opaque depending on the application onto the drawing paper support. The colors may be built up in layers or applied lightly, letting the grain and

Figure 5–12 Oil sticks, pastels, and colored pencils are dry-pigmented colored drawing materials. From the top: chalk pastel, colored pencil stick, and oil pastel. Courtesy of Becky Koenig.

whiteness of the paper show through. They are a convenient way to make both quick color plans and finished drawings.

Wax crayons have the same binder as encaustic paint, but they are used as a dry media on paper. They are essentially pigments or dyes mixed with paraffin wax to make colored sticks. We usually think of crayons as a child's art material, but there are also wax-based colored drawing sticks for artists on the market.

Chalk pastels are dry pigments with a very minimal glue binder called gum tragacanth. The chalk pastels are made of a glue solution of precipitated chalk and pigment. These ingredients are mixed together then formed into sticks and dried. Since this is an opaque medium, tints are made in premixed color sticks with gradated additions of white pigment, and shades are made with the gradients of black pigment. Pastels are best used on a medium-textured paper surface. Pastels can be drawn onto toned papers (for example, a gray paper), which bring out the sparkling quality of the colors. Pastels are easily blended with the hand or a with a paper blending stomp. Their portability makes them an ideal painting medium for working outside. Pastels may be lightly sprayed and fixed but have a delicate surface and should always be professionally displayed under glass.

Oil pastels are colored sticks that are made of pigments or dyes in an oil/wax binder. Oil pastels do not dry, but retain a somewhat sticky surface. They can be drawn onto paper and blend easily into each other or can be blended with mineral spirits or turpentine. Be aware that there are many inferior grades of this material on the market. For permanent work, only use those graded as artist quality.

Oil sticks are actually oil paint in stick form. The sticks form a skin but stay wet inside. They should be used on a primed ground as oil paint and can be blended with turpentine and oil paints. See Table 5.2 for a comparative chart of pigmented materials.

Inks and Dyes

DYES Dyes are soluble colorants. Dyes transfer color by being dissolved in liquid and then staining or absorbing into a given material or surface. The lightfastness of dyes is variable—they are not all as lightfast and stable as artist's pigments. There are two major sources for dyes: natural (animal or vegetable extracts) or synthetic. Some fiber artists prefer natural dye agents such as indigo, cochineal, and madder, which are older organic pigments no longer in use in paints.

The number of dyes used for textiles is enormous—over ten thousand. Synthetic fabric dyes are fiber-reactive dye, disperse dye, vat dye, and procian dyes. Natural dyestuffs will only adhere to natural fabrics, so synthetics are widely used on commercially produced fabric. Procian dyes, while offering a large range of bright and permanent color for textiles, are highly toxic.

TABLE 5.2

CHART OF PIGMENTED MATERIALS

Media	Binder	Additive	Solvent	Support	Opacity	Property
Encaustic	Wax	Gum		Wood panel	Translucent	Must be heated to paint with
Fresco	Lime plaster	None	Water	Lime plaster on wall	Translucent	Must be painted on wet plaster
Egg tempera	Egg yolk	Oil	Water	Panel with gesso	Translucent	Must be painted in thin layers
Oil	Linseed oil	Resins, oils, or waxes	Gum turpentine or mineral spirits	Primed wood or canvas	Opaque or transparent	Slow drying glazes to impasto
Watercolor	Gum arabic	Gum arabic	Water	Watercolor paper	Transparent	Thins with water
Gouache	Gum arabic		Water	Watercolor paper	Opaque	Thins with water
Acrylic	Polymer resin	Polymer medium or gel	Water	Almost any	Opaque or transparent	Fast drying, any thickness
Chalk pastel	Gum tragacanth		Dry medium	Paper	Opaque	Dry, blends easily
Colored pencil	Wax and clay		Dry medium	Paper	Translucent	Smooth or textured
Oil pastel	Wax and oil		Turpentine	Paper	Translucent	Blends easily
Oil stick	Linseed oil		Turpentine	Paper or canvas	Opaque	Like oil paint

DYES IN ART MATERIALS Dyes are also used in various art materials. Most felt-tipped markers, for example, are filled with dyes rather than pigmented material. In order for colors to flow properly through a fiber point, they must be liquid dye. Markers are convenient when used for execution of architectural renderings and quick compositions for graphic design; they are available in a wide assortment of colors for these purposes. Markers are a transparent medium and are layered for a wide range of effects. Alcohol-based markers blend into each other easily. Water-based markers can be layered with less blending. Both types of markers bleed and absorb into the paper surface to stain the paper with their dyes. Markers should not be regarded as permanent art materials for fine art or design. There are a few markers that use pigmented ink, mostly black, which should make them more lightfast. There are also "paint" markers, which contain an enamel paint that is released to flow by a pump mechanism. All markers are questionable as to permanence and should be subjected to informal light testing before use for permanent work. Dyes are also used as coloring agents for both ink jet printers and photography.

INKS Ink is a term for a large variety of art materials. Inks refer to both physical materials and process materials. There are drawing inks, printing inks, process inks for commercial printing, and printing inks for fine art printing.

India ink is a pigmented black ink that has been in use for several hundred years. [5.13] India or China ink was originally available in a stick form that was subsequently ground and mixed with water to make a black, permanent ink. India ink now refers to a black waterproof drawing ink made with carbon black combined with a shellac binder and to be used on paper. India ink is different in composition from writing ink for fountain-type pens. Writing ink is dye based and water soluble. There are also colored inks that can be brushed on or applied with dip pens. Colored inks that are dye based are of questionable permanence. Other dye-based materials that are subject to fading are the liquid "watercolors" in dropper jars. These are appropriate for graphic design, but because they are dye based, they may fade or change color. Pigmented colored inks can be applied by a brush, pen, or airbrush (a spray-painting device). Pigmented inks are higher in colorfastness than dye-based inks.

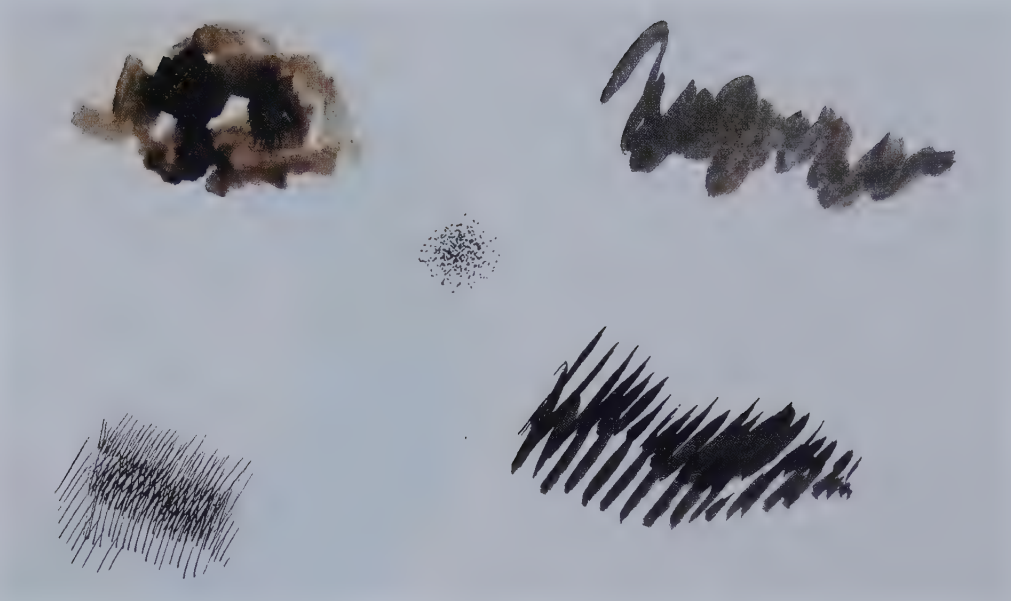


Figure 5–13 India ink is a combination of carbon black and a shellac binder. Courtesy of Becky Koenig.

The permanence of some questionable materials can be tested at home for color- and lightfastness. Swatches of all the questionable materials can be put on a paper or board, complete with labels. Half of the board should be covered with a heavy black paper. Placement in a south-facing window for a month or more should indicate any fading that will occur. The black paper is then removed to compare exposed with unexposed areas.

PROCESS MATERIALS

Color Photography

Color photography is based on the principles of tricolor theory and the interplay between additive and subtractive color systems. Color photography has evolved from a film process to an electronic digital process over the past century. Color photography was first introduced in 1907. The color image was created by a series of films exposed with separate color filters to make three color images. Color film was made of three light-sensitive layers. Each of these layers recorded one of the primaries of additive light: red, green, and blue. Each portion of the image was actually recorded as a black and white using silver halide, which was subsequently washed away in processing. This left three dye colors: the three subtractive process primaries of cyan, magenta, and yellow, one color on each layer of the three-layer film emulsion. Dye couplers, color formers that were activated in the film development process, formed the dyes.

The photographic process involves the additive color system, with an additive color circle as its reference. [5.14] The secondary colors of light are the three subtractive process primaries, cyan, magenta, and yellow, which are the complements to the additive primary colors. When color film is exposed to a subject, the light hits each layer of film, and the additive primaries of red, green, and blue change in color to their complements. The complements of additive colors are cyan (from red), magenta (from green), and yellow (from blue). In film, the red-sensitive layer records as cyan, the green layer as magenta, and the blue layer as yellow on the developed negative. [5.15] The color black in an image does not expose any emulsion, and white exposes all three. Black is open on the negative, thus it is a combination of cyan, magenta, and yellow. White is black on the negative, thus blocking all color development in these areas on the positive print.

The photographic positive is made on special color print paper that also has three layers of light-sensitive emulsions. These are in reverse order when compared with the

Figure 5–14 The photographic color circle is identical to the additive color circle. The complements determine how each color filters another in photography.

Figure 5–15 How light is filtered to produce a color on a photographic negative.

film. The top layer is cyan; the middle, magenta; and the bottom layer is yellow. To make the print, the negative is projected through an enlarger either sequentially to red, green, and then blue light or to a balanced white light. Since both the negative and the positive print are formed from dyes, color photography is subject to fading. Care must be used in protecting framed images with glass, especially glass that controls ultraviolet rays.

Digital Photography

Within the last ten years, there has been an almost complete shift from color film usage to digital photography. The advantages of digital cameras are numerous: The images can be viewed on a small LCD screen on the outside of the camera before taking them, and

photographs can also be scrolled through on this screen after they are taken. Images can be viewed, deleted, and loaded onto a computer for cropping, editing, making color adjustments, and balancing. All of these options give the casual and professional photographer much more control over the final images, the type of control that only professional photographers had when using film.

Digital cameras operate and collect visual information in a different manner than traditional analog cameras. Digital cameras use millions of pixels to produce a photographic image. When the shutter is pressed on a digital camera during the exposure time of each picture, each pixel has a *photosite* that is uncovered to collect and store photons. A *photon* is the smallest measurable particle of light. When the exposure is finished, the camera closes the photosites and then assesses the number of photons in each cavity. The number of photons in each cavity is then sorted into varied intensity levels that are determined by bit depth (see Chapter 6).

Each cavity has a filter that lets in only one of the RGB components of light in each exposure, thus two thirds of the incoming light is discarded. A common color filter system is called *Bayer array,* which has alternating rows of RG and BG filters. In this system, there are twice as many green filters as red or blue because the human eye is more sensitive to green light. To translate the Bayer array of RGB light into a complete image, a process called *demosaicing* completes the digital image. This proportion of RGB forms a finely detailed image. Some cameras have alternate systems for capturing RGB light during exposures by which each pixel is able to capture R, G, and B in each pixel.

A *histogram* is a chart that is useful for understanding the values and RGB components of each image. There are RGB histograms for color analysis and luminosity charts for evaluation of image values. This chart is a way in which the computer analyzes each image in graph form by mapping shadows, midtones, and highlights. The tonal range of each histogram represents the characteristics of each image. If the image is high contrast, the tonal range's peaks will be broadly separated; if heavy in midtones, the graph for an image will peak in the center, and so on. Understanding histograms helps the photographer choose camera settings as well as edit the photos on the computer.

Color Printing

Color printing refers to two types of printing processes: first, processes used for commercial reproduction of type, text, and image; and second, processes used by artists for fine art printing. Printing always refers to the transfer of image from a special surface (a plate, block, or stencil) by ink onto paper. Print processes can be roughly divided into four major areas: relief printing, intaglio, screen printing, and lithography. There are fine art and commercial processes within each area.

Relief Printing Relief printing utilizes the raised and recessed areas of metal plates or wood blocks to form a printed image. Types of relief printing include woodcuts, wood engravings, and letterpress for commercial work. To make a relief print, ink is rolled onto the raised areas, and a lightweight paper picks up the inked areas by the pressure of a press or hand. [5.16] Raised areas of the block or plate are printed, and recessed areas remain white as unprinted areas. Any number of colors can be used, but each color is a separate print run from different block surfaces. For wood relief printing, either oil-based or water-based inks are applied to the block with a rubber roller. Among the finest examples of wood block printing are the Japanese woodcuts, which have been refined to a high art form. [12.6]

Letterpress is a form of relief printing that uses a photosensitizing process to etch a metal plate. After etching, the remaining raised areas are alternately inked and printed by machine. Letterpress was in use until the 1960s, when other more efficient printing procedures replaced it. It has had a strong resurgence in the creation of artist's books and is still used primarily by small printing companies for high-quality bookwork.

Intaglio Printing In intaglio printing, metal plates made of steel, zinc, or copper are used. These plates are etched by acid or hand engraved to form recessed areas. The plate is fully inked and then wiped by hand or scraped by machine to force the ink into the

Figure 5–16 A cross-section of a relief-printing block. The raised areas (red) print, and the recessed areas do not.

recessed areas of the plate. The inked plate is then run through an etching press equipped with heavy rollers, and the image is transferred onto a dampened sheet of paper. The recesses can be either line or textured areas. In fine art processes, such as etching, the heavy oil-based pigmented ink is applied to the plate by hand and then wiped. Intaglio processes include dry point, etching, metal engraving, aquatint, photo etching, and the commercial process of gravure. Gravure printing is often used for large printing jobs, the costs being too high for smaller jobs. In the gravure process, ink is rolled onto the plates and then scraped by a thin steel blade to force ink into the recessed areas. Gravure printing of photographs is considered a superior method due to the higher contrast that it provides.

LITHOGRAPHY Lithography was developed in the nineteenth century. Lithography was used for art printing, as its process was quicker than that of either etching or engraving. In lithography, an image is drawn with a grease-based material on a specially ground stone or metal surface. The printing process involves oil and water, which resist mixing. A thin film of water keeps the ink on the oil-sensitized areas of the surface and away from other surfaces. Offset lithography is a primary means of commercial printing for books, magazines, and art reproductions. The offset process uses a thin metal plate to offset the image onto a rubber mat, which is then printed onto paper. Both etching and lithography use heavy oil-based pigmented inks that have a sticky consistency.

SCREEN PRINTING Silkscreen or screen printing involves a special fabric screen that employs a handmade or a photosensitized stencil method to produce prints on paper or fabric. The screen is a fabric that is stretched over a simple wooden frame. [5.17] The prints are made by using a squeegee to force ink through the screen. To produce a print, open areas of stencils allow the ink to pass through the screen to a sheet of paper underneath. Silkscreen is manually produced both for artists' prints and for larger commercial production. There are also semiautomatic presses, which are hand fed with paper. Fully automatic machines print large editions of posters. Screen-printing ink adheres to many surfaces, including plastic, paper, metal, glass, and fabric.

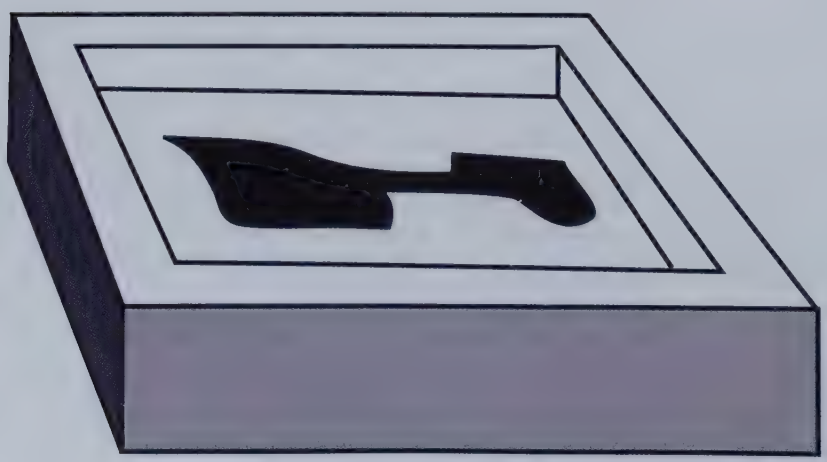


Figure 5–17 In a silkscreen print, a stencil on the screen controls the areas to be printed.

Figure 5–18 A silkscreen print by Andy Warhol shows his innovative use of color combinations produced in a series of prints. Andy Warhol, *Marilyn Monroe* (1967). One of a portfolio of ten screenprints on white paper, 36" × 36". © 2011 The Andy Warhol Foundation for the Visual Arts, Inc./Artists Rights Society (ARS), New York Photo Credit: The Andy Warhol Foundation, Inc./Art Resource, NY.

Andy Warhol, the U.S. twentieth-century "Pop" artist, integrated silkscreen printing as a primary part of his painting process. Through the screen print process, Warhol could integrate photo-based imagery into his paintings; the images were screened onto canvas as one of the final layers of each painting. Warhol also produced many portfolios of screen prints with color variations on identical images. Silkscreen inks provided Warhol with a commercially produced color palette that freed him from historical color constraints. [5.18]

Color Reproduction

Commercial color printing has two principal processes to reproduce color, namely, color separation and flat color.

Commercial Printing

Commercial printing from a professional press is a process of reproducing text and image through a large-scale industrial process, an essential part of publishing. Offset printing is the most common form of high-volume commercial printing because of its suitability of both quality and efficiency for high-volume jobs. Modern digital presses are becoming a viable option for low-cost, good-quality printing but cannot yet compete with the production volume of an offset press. Many modern offset presses are now using computer-to-plate systems to further increase the quality of printed materials. For information on digital printers, see Chapter 6.

TRADITIONAL COLOR SEPARATION Color separation is a method of isolating the component colors of a full-color photo, painting, or illustration for reproduction purposes. Three photographs of an artwork are shot, each through a separate color filter. The filters

are meant to calibrate exactly with each wavelength of the three light primaries. Before electronic digital imaging was developed, the traditional method of color seperation was to photograph the image three times, using a filter for each color. The first photomechanical color separation was produced in 1893. The quality of a reproduction is directly related to the quality of the filters used. Each photo records one third of the color information, which parallels the photographic color process discussed previously.

Digital Color Separation Digital color separation employs a digital scanner to separate the original artwork into red, green, and blue components. The next step is to invert each of these separations as follows:

- The red filter removes red and leaves green and blue, making cyan.
- The green filter removes green and leaves red and blue, making magenta.
- The blue filter removes blue and leaves red and green, making yellow.

Each separation thus results in the process complement of each additive color. [5.19] This occurs because cyan, magenta, and yellow are subtractive primaries that represent the mixture of two of the three additive primaries (RGB). Cyan, magenta, and yellow (CMY), the process primary colors, are the three main pigments/dyes used for color reproduction. When CMY colors are combined in printing, the result should theoretically produce a true representation of the original image, but in practice this does not work. Due to limitations in the ink pigments, the darker mixtures of CMY make unpleasant muddy colors. For this reason, a black separation is also created, to enrich shadows and image contrasts. Black is included in the four-color process also because text is printed in black and can configure fine detail such as serifs.

Four-Color Process In the four-color process, printing inks are transparent, which means that color mixing occurs through color layering and unprinted areas of open white paper that represents white. Cyan, magenta, and yellow mix in various intensities to produce most colors, C and Y forming greens, M and Y making oranges and reds, and C and M producing violets and blues. Unlike photography, in commercial printing, cyan, magenta, and yellow alone are not adequate to reproduce a full-color continuous tone image. A fourth color separation with a neutral filter allows black to be added to sharpen, darken, and define the image. [5.20] Thus, the four-color process is called CMYK, standing for cyan, magenta, yellow, and black or "key." Today, digital scanners or work that

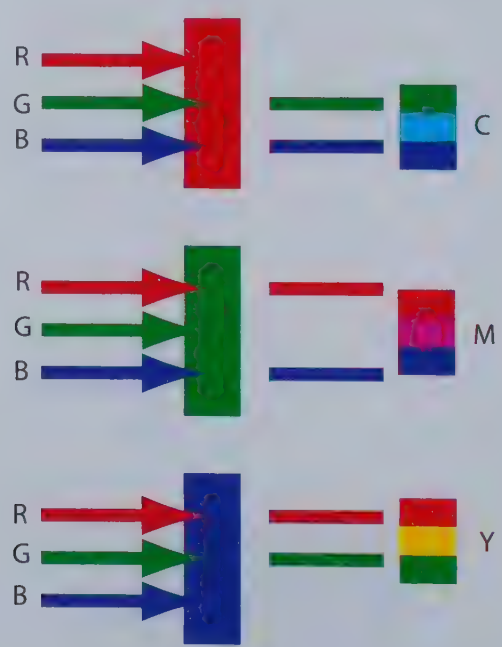


Figure 5–19 How colored filters separate colors for the four-color printing process (CMYK). Courtesy of Becky Koenig.

Figure 5–20 Color separations are overprinted in stages as shown, starting with yellow and ending with black, for four-color, commercial, printed matter. Courtesy of Becky Koenig.

is digitally produced directly in CMYK mode produces most color separations. Original art can be put through a scanner with high-intensity light or laser to separate the colors. Color filters are built into the scanner, which then converts the image into a four-color separation. The resolution of the scanner can be set according to the resolution and paper that are desired for the final print of the image.

The four-color process of printing is actually a pattern of tiny dots, which are round, elliptical, or square. By their density, these dots produce variety of both color value and saturation in the final image. Screens that generate these dots vary according to the desired resolution of the printed image and the type of paper onto which it is printed. A *halftone* is a pattern of dots used for reproduction of a continuous tone image. These dots are called Benday dots after their inventor, a New York printer named Benjamin Day. Benday dots gradate in size to suggest light or dark areas of the image by optical mixtures. While the dot pattern remains consistent, dots in dark areas are larger to cover the white paper surface more densely. Dots are smaller in light-value areas so that the white paper optically mixes with small areas of color to visually produce tints. Gradation of the size and overlapping of dots creates the illusion of smooth value, hue, or tonal gradations. A screen pattern of dots or dpi (dots per inch) can be finer or coarser depending on the desired resolution of each printing job. [5.21] The combination of CMYK dots in various sizes and overprinting of transparent ink colors creates optical mixtures that give the illusion of a wide array of colors. The photographic or digital color separation determines proportions of each CMYK color area that is screened to create a dot pattern.

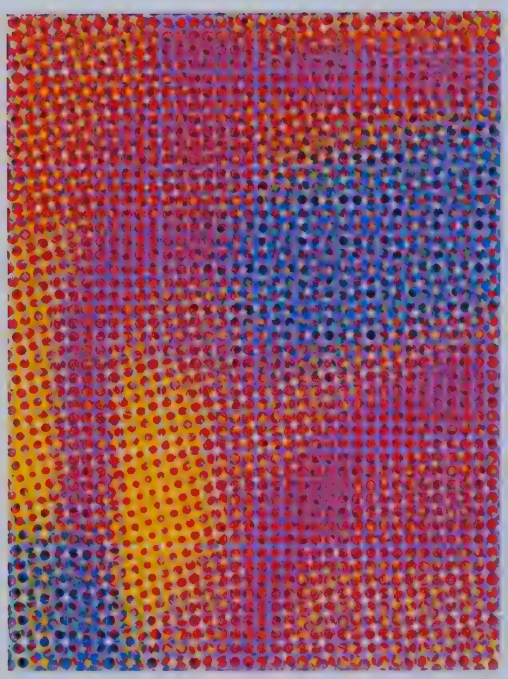


Figure 5–21 Large-scale halftone dots shown here indicate the changes in pattern structure that occur to produce values.

The dots are graded in lines per inch. [5.22] These can be roughly sorted in quality as follows:

- Newspapers: 85 lines per inch
- Magazines: 133–150 lines per inch
- High-quality art reproductions: 300 lines per inch

The four-color process is printed in layers in this order: first yellow, then magenta, then cyan, and then black. [5.19] Dot screens are placed at different angles to avoid a wavy effect called a moiré pattern that can occur in the final reproduction.

EXPANDED CMYK When more color accuracy is desired, up to eight colors can be used for process printing. Processes such as Pantone's six-color (CMYKOG) Hexachrome® substantially expands the color range of a printing project because of the addition of orange and green inks. Pale, saturated colors are often difficult to create with the restrictions of CMYK inks, which sometimes make a halftone pattern visible in light colors. An alternative to traditional CMYK printing is CcMmYyKk color, in which there are lighter versions of cyan, magenta, yellow and black (represented by the lower case letters) that allow pale colors to be more densely printed, with a less visible halftone pattern.

To ensure color consistency, printers use color control bars called SWOP, which stands for "specifications web offset productions." Variations in the colors of CMYK inks are dependent on the manufacturer, which is important to know at the outset of any printing job.

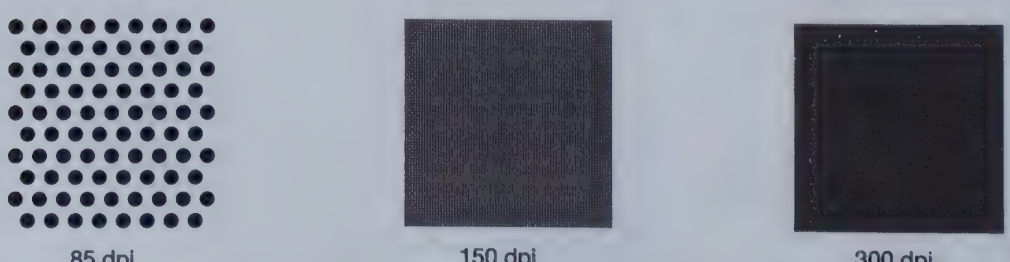


Figure 5–22 An example of 85, 150, and 300 dpi dot screens of printed matter.

FLAT COLOR Flat or spot color is a solid, printed color area selected for some one- to three-color printing jobs or to add a specific custom color to a four-color printing job. The colors are chosen from a PANTONE MATCHING SYSTEM® or process color chart. The PANTONE MATCHING SYSTEM® has upward of one thousand spot colors. Choosing colors from the PANTONE® chart allows the printer to exactly duplicate a particular color choice.

The materials of color range from the traditional pigmented materials that artists have always used to sophisticated process photographic, digital, and print tools of ever-increasing complexity. These tools allow the artist and designer to communicate more widely with color than ever before.

ACTIVITIES

1. COLOR TESTING

Objective: To learn about the permanence and paint quality of a variety of colored art materials.

A. Lightfastness Tests

- Make a color test strip on a small piece of board. Make marks of colored markers, colored inks, digitally printed color, writing pens, paint markers, or colored pencils on the board. Use colors that are both pigmented and made from dyes. Try many different colors and coloring materials.
- Make sure that each item is labeled. Cover half of each mark with black paper.
- Put the test strip in a sunny, south-facing window for at least one month.
- Remove black paper and note any fading or color changes.

B. Paint Tests

- Using acrylic, gouache, and watercolors, test the paints for opacity by painting a strip of each color on black paper or on a black strip of paint.
- Paint out a thick swatch of each color and then test the undertone of some of the colors by spreading each pigment out thinly next to each thick swatch. [5.5]
- Try adding the same amount of white to two or three different pigments. Be careful to use the same amount of white for each color. How do the tinting strengths of each one of the pigments compare?

COLOR MATCHING MIXTURES

- Pick flat color swatches from magazine pictures, printed matter, wrappers, packaging, printed digital color swatches, and so on. Choose at least six different found color swatches.
- Using pigment mixtures, try to exactly match the found colors. Use the pigment color chart as a guideline. Keep in mind prior mixture exercises, value mixtures, complementary mixtures, and hue variations to guide your choice of color mixtures.
- Present the found colors and mixtures side by side. Which colors were the most difficult to emulate accurately?

2. PIGMENTS AND HUES—MIXTURE VARIATIONS

Objective: The secondary mixtures of primary hues can vary by the types of primary pigments used. The student will learn how the coolness, warmness, and opacity of pigments will affect pigment mixtures.

- Mix several variations of secondary hues by using different primaries. Try cool with cool and warm with warm or cool with warm. For instance, use a Cadmium Red (warm) and an Ultramarine Blue (cool) to make a violet. Now try a Quinacridone Red (cool) and a Phthalo Blue (cool). How do the mixtures vary? Which one is higher in saturation and why? Try to make two versions each of green and orange as well. Now try making tertiary hues from varied pigments. [5.23]

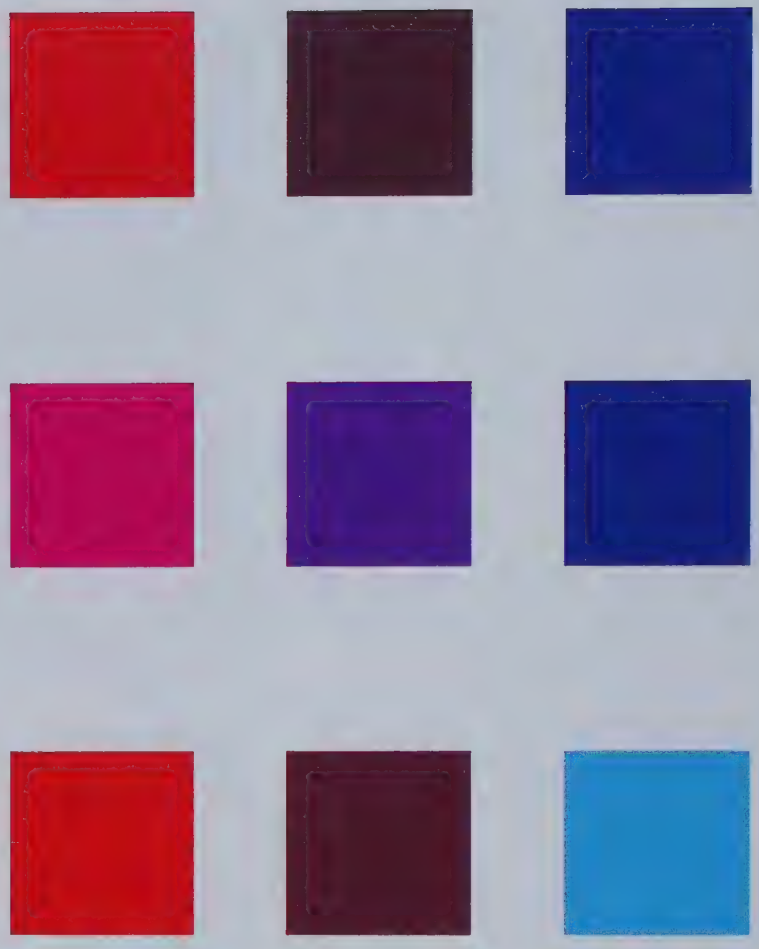


Figure 5–23 To learn about the nature of pigments and their mixtures, we can mix secondary and tertiary colors from a variety of primary-hue pigments. Shown here are different reds and blues and the violets that they make when mixed. From the top row down: The top mixture shows a warm red, such as Cadmium Red and a cool Ultramarine Blue. Second row shows a violet mixed from a very warm red, Cadmium Red Light and the same cobalt blue. The third row shows a Carmine Red and a warmer Cerulean Blue. The fourth row has a Quinacridone Red, magenta mixed with Cobalt Blue. Each mixture results in a different violet.

GLOSSARY

COLORANT A compound that imparts its color to another material.

COLORFASTNESS Defined as the resistance of a color to the loss of its original color quality. High colorfastness means that a color will not darken, fade, bleed, or wash out.

DYES Soluble colorants. Dyes transfer their color by being dissolved in liquid and staining or absorbing into a given material or surface.

HALFTONE A *halftone* is a pattern of dots used for reproduction of a continuous tone image.

OPAQUE Refers to media through which light cannot pass. Opaque paint is also called body color because it uses white as part of the paint mixture and completely covers the surface onto which it is painted.

PHYSICAL COLOR MATERIALS Those materials that are used directly, such as paints, colored drawing materials, and textile dyes.

PROCESS COLORS The four colors used for commercial printing and color photography: cyan, magenta, yellow, and black, also abbreviated as CMYK. Cyan, magenta, and yellow are close to the traditional subtractive primary hues of red, yellow, and blue. The CMYK color mode on computer is meant to match with process printing colors.

TRANSPARENT MEDIA Media that light can pass through to the support below. Watercolor, oil glazes, markers, dyes, and some inks are transparent.

VEHICLE OR BINDER Pigment is mixed with a vehicle or binder to become paint. A vehicle or binder must support and bind pigment particles as a well as ease the application of a pigment to a surface.

Chapter 6

Digital Color

LEARNING OBJECTIVES

- To understand the relationship of digital color with color theory, through the digital modes of RGB, CMYK and HSB (hue, saturation, and value or brightness).
- An overview of how digital color works: pixel depth, digital color models, and gamuts.
- A review of some basic functions in graphic media that introduces the student to electronic production of color studies.
- An overview of methods of photoimage adjustments and file formats of photographic and graphic files.
- An introduction to digital color mixing and color libraries.
- Forging a working relationship between digital and analog processes.

INTRODUCTION

The advent of digitally created art and design has shaped a rapid development in electronic color. Digital media is ever evolving due to rapid, simultaneous advances in computer hardware and software. This chapter explores information about digital color, its background, models, and characteristics of electronic media. Working knowledge of digital color models is integrated with and expands upon the concepts of color theory.

Digital media supplies a huge color vocabulary to the artist and designer across media and devices. When we are working digitally, the standard color palette is 16 million colors but also can range up to 281 trillion colors. Digital color thus offers the artist or designer access to a staggering number of color options. This chapter provides a broad knowledge of digital color, how it relates to color theory concepts, and some simple applications of electronic color through software functions and tools.

DIGITAL COLOR BASICS

Electronic media is the primary tool for design; drafting, animation, illustration, type and image, page layout, photography, printed media, electronic forms of painting and drawing, and web design, which can all be produced digitally on computer. The emphasis of this chapter is on the fundamental aspects of electronic color.

THE COLOR DISPLAY

The display monitor on a computer or other device has an illuminated screen, the surface of which is a grid, and each unit of the grid is called a pixel. The word *pixel* is a combination of the words picture and element, hence a pixel is a "picture element." Pixels are arranged in rows called *rasters.* The number of pixels or the fineness of the pixel grid is measured in *ppi* (pixels per inch). Ppi determines the resolution of the monitor screen. On a traditional cathode ray tube monitor (CRT), each pixel has tiny spots of phosphor, a chemical that can emit light. At the rear of a traditional cathode screen is a device called an electron gun, similar to that used in a video screen on a TV. The electron gun fires beams of electrons at each pixel in a particular order. Each dot is either illuminated on or off during this process. Three electron beams can activate these three separate spots of phosphor, one for red, one for green, and one for blue (RGB). The RGB range in a CRT monitor is smaller than the range of spectral colors as colors made from phosphors are not as pure as true spectral primaries. The limitation of any display screen's limited color range (in relationship to the color range of what we actually perceive in reality) is called a color *gamut.*

Most often used today, thinner, flat display screens utilize LCD technology, an acronym for *liquid crystal display*. LCD is the established format of most display screen devices such as computers, cell phones, tablet computers, eBooks, and so on. The LCD screens are brighter, more compact, and significantly different from CRTs. LCDs display in one optimal resolution, have a smaller viewing angle and a lower radiation emission, have no flicker or distortion, and use less energy. In LCD technology, a light source filters through the liquid crystal, bending and twisting light to display colors and images. LCDs have pure RGB filters so the color distortion of phosphors does not occur, displaying true RGB colors with more saturation and brightness.

All display screens show colors with actual light in additive color. Basically, a color screen paints and draws with light.

BIT DEPTH

To grasp the concept of pixel or *bit depth* in reference to digital color, we need a basic understanding of the digital operational system of a computer. A *bit* is the smallest unit of information utilized by a computer. A bit is equivalent to a single electronic pulse, which can be either on or off. One (1) is the numerical code for on, and zero (0) is the number code for off. This is the basis of the *binary system,* a two-number system that is the code for all the information contained in a computer. Pixels either turn on or off contingent upon the coded information sent by the computer to the monitor. Older computer monitors had one-bit pixels, which meant that a pixel was either on (illuminated) or off (darkened). The illuminated areas of the screen were either white or green and could display text, line art, or simple shapes. Two-bit screens were subsequently developed, which meant that each pixel was capable of holding two bits of color information. Two bits per pixel meant that a monitor had four colors: black, white, and two gray values. Thus, the higher the bit number, the more colors that can be displayed on the screen. An 8-bit pixel displays 256 colors or a gray, as 2 to the 8th power mathematically forms 256 distinct combinations of color information. Each bit also has "depth" or different levels. On a 4-bit monitor, the four on and off signals can be arranged in 16 different ways. The colors that we see onscreen due to bit depth are dependent on the arrangement of the bits in various layers. [6.1] Bit numbers correlate to the number of colors displayed on the screen in historical order as follows:

1-bit, 2 colors, black and white
2-bit, 4 colors, black and white and two grays
4-bit, 16 colors
6-bit, 64 colors

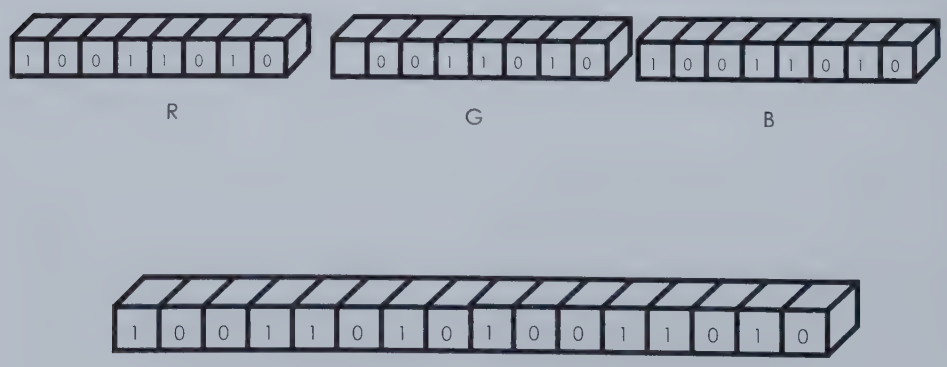


Figure 6–1 Bit or pixel depth determines the number of colors that can be displayed on the computer screen. Each bit is either on or off in combinations that determine the overall color of each pixel. Shown here are an 8-bit depth that makes 256 colors and a 24-bit depth that can form 16 million colors.

8-bit, 256 colors
24-bit, 16 million colors
30-bit, over 1 billion colors
48-bit, 281 trillion colors

Most computer screens have 24-bit color or *true color*, which is photographic quality color on the screen display. Twenty-four-bit color has 8 bits of memory for each hue, also known as channels, red, green, and blue, and results in over 16 million colors that, when exponentially calculated, are the numerically possible combinations of color information.

There are several newer and larger-scale RGB modes. The first is 32-bit RGB, which displays the same 16.7 million colors as 24-bit true colors but has a much higher capability of speed, transparency, and blending. *Deep color* is a color range of more than 16 million colors, which also stores the colors at a greater rate of accuracy of bit depth. Thirty-bit integer RGB has 10 bits per channel resulting in 1,073,741,824 colors (over one billion). Forty-eight-bit integer RGB representation is high-precision color stored in 16 bit channels with 48 bits of color per channel, resulting in 281 trillion colors. Deep color has more colors than we can possibly visually distinguish and perceive.

BITMAP AND VECTOR-BASED PROGRAMS

There are two principal methods that form and digitally manipulate images. These are referred to as either bitmap or vector-based modes.

Bitmap

Bitmap images employ pixels to generate areas of color on a digital screen; they are also called *raster* images. Pixels fill the display screen in horizontal and vertical rows to build bitmap images. Painting programs and photo-editing software are based on bitmap images. Bitmap software is effective for photo images because of the need for continuous tones. Painting programs are also bitmap based so that digital "painting" can have the character of paint: blended colors and gradations. In bitmap programs, pixels define image areas; when images are enlarged, they lose definition, and the jagged edges of the pixels become visible. A bitmap program controls pixels in a fine mosaic rather than lines or shapes. [6.2] Gradations are created through optical mixture of colors in the pixel mosaic to create tones that, in turn, form images. Bitmap images are *resolution dependent,* which means that image resolution depends on the display monitor and the scale of the pixels themselves. Resolution refers to the number of dots or pixels per unit used to reproduce or create artwork. Although the computer itself controls pixel resolution, on a larger screen the individual pixels may become more evident. This is called pixelation. Higher resolution uses a grid with a greater number of pixels, which gives an image a smoother, finer-grained appearance.

Vector

Vector-based programs are based on line drawing. Defined by math objects called *vectors,* vector images portray shapes according to their geometric plan. Vector programs use mathematical locations or points to form lines and shapes, which then build into images. The advantage of a vector-based graphic program is that the images are *resolution independent;* that is, the images can be enlarged or reshaped without losing their clarity. [6.3] A vector-based program is more precise than a bitmap program and allows more flexibility for change. The file sizes of vector art tend to be smaller than bitmap or raster image files. Vector programs are a good choice for type, logos, drafting, and clean-edged work drawn with straight lines, freehand lines, and Bezier curves (curves plotted by anchor points). Vector programs also include a limited amount of painting capability to create softer effects. Vector images cannot be seen with complete accuracy on a monitor because they must be displayed in a pixel format. A good printer converts vector lines into dots through a process called rasterizing to improve the printed final product.

Figure 6–2 Above, pixels or rasters can become evident when a bitmap image is increased in size, compared to the crisp edges of the vector image to the right.

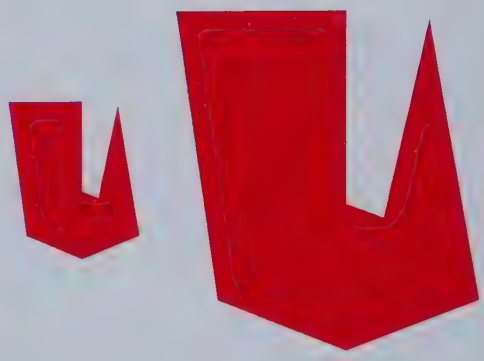


Figure 6–3 A vector image maintains a crisp outline despite its size since it is based on a computer line drawing.

TYPES OF DIGITAL SOFTWARE

Digital software is used for drawing, painting, image editing (for photography), page layout, and drafting. Some programs are designed for static art, and other software is designed for time media, such as video editing and computer animation. Drawing software is vector based and has drawing, limited painting, and typography capability for graphic design and illustration. Bitmap-based painting programs have the capability of simulating the effects of traditional drawing and painting media. Image-editing software is designed for manipulating photographic material, which is scanned in or loaded from a digital camera. Photo software is bitmap based to supply the continuous tones needed for photographic imagery. Page layout programs assist the designer in formatting print-ready materials, illustrations, photos, and type. Drafting programs are used for architectural drafting and linear perspective presentations. Computer-aided drafting software can also control and guide the fabrication of three-dimensional sculptural or architectural forms.

IMAGE FILE FORMATS

There are numerous types of image file formats, which organize and store digital images of either pixel-based or vector data for use in digital media. Image sizes are compressed to decrease the size of each file to manageable levels, so they occupy less space on a hard drive or another storage device. There are three formats most frequently used for web images: JPEG, GIF, and PNG. JPEG (Joint Photographic Experts Group) files were specially developed for continuous-tone photographic files; they are compressed raster 24-bit files. A JPEG file is a highly compressed file, reducing file size by 10:1 and is an example

of *lossy* compression. *Lossy* refers any method of data compression that reconstructs the original data approximately, rather than exactly, with minimal change in the image.

There is also a JPEG XR that has deep color capability (32-bit or higher) and a JPEG 2000, which is used in video editing. GIF (Graphic Interchange Format) files are used to compress illustrations (raster) and graphic files (vector) with either solid color or animation. A newer version of the GIF format is PNG, which has a larger 24-bit color capability. TIFF (Tagged Image Format) files are widely used in publishing and can be raster-based RGB, CMYK, Grayscale, LAB, or indexed color; however, TIF files are not supported by all web browsers. Compression in these files is considered to be *lossless*, meaning that they compress data well with no loss of color information.

Files that contain mixed data such as pictures and text are often saved in PDF format. Vector-based formats include CGM, Computer Graphics Metafile, which supports a 2D vector graphics, and SVG, Scalable Vector Graphics, an all-purpose vector format for the web.

DIGITAL TOOLS

Toolbox

Digital graphic programs provide the artist with a workspace (sometimes called the paper or art board) image area on the display screen, a toolbox, and a huge range of colors. Digital tools are activated by clicking, manipulating, or dragging with a mouse or using a stylus and tablet. Graphic tools are either for creating images or have image-editing (photo or other given image) capability. Shown here are the toolboxes from Adobe Illustrator® and Photoshop®. [6.4]

Tables 6.1 and 6.2 supply brief descriptions of some of the common image-making and editing tools found in graphic software along with examples of their use. [6.5] Digital software programs are updated on an almost continual basis; the tools are refined, are more sophisticated, and have added functions. [6.6]

Image-making tools in either bitmap-based (Adobe Photoshop) or vector-based (Adobe Illustrator) software are tools to draw, paint, and create shapes or type. Image-editing tools affect or change a given image (either made by the artist or photographic) in varied ways, changing the contour of an image by tools like blur, pucker, and bloat. [6.7] There are also effects that filter the individual object's visual characteristics such as extrude (a 3D effect), drop shadow, and pixelate. [6.8]

When a computer object is selected, it can be manipulated in a huge number of ways. Digital tools should be applied with spirit of experimentation and time to grapple with the often steep learning curve of various programs. Online instructional tutorials, reference materials, and search terms are an essential part of this process.

The functions of graphic tools vary depending on whether they are vector format, which is line based, or bitmap, which is a pixel-based format for drawing, painting, or image modification. In photoimage-editing software, much of the functionality applies to the modification of an image's color, texture, or contrast, in addition to altering the image itself by distortions or cutting and pasting images together. Vector software is suitable for line-based graphics with clean edges and solid color areas. Painting software is aimed toward directly working with tools that simulate real painting and drawing effects. Most graphic software controls image creation with a set of tools such as pencil, pens, and airbrush, which are selected from specific palettes or customized to the artist's specifications.

In addition to image creation tools, there are also palettes of premade textures, graphic styles, and symbols to pick and apply to areas or objects. [6.9]

Filters

Software can distort, change, and modify images with the use of *filters* or *effects*, which automatically transform the appearance of a computer drawing or one based on a photographic source. Because each filter alters an image in a particular way, it is useful for the student to become familiar with filters and their use in the creation of visual effects, see [6.10] for some examples of filter effects.

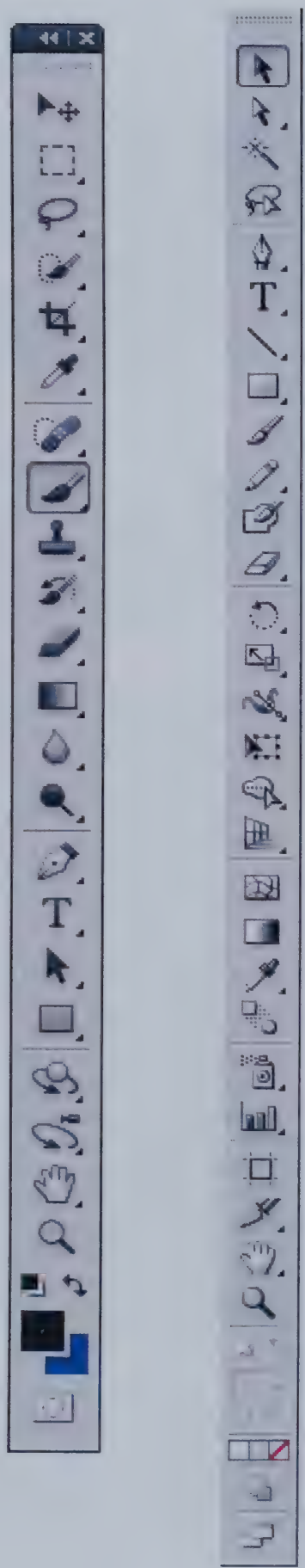


Figure 6–4 Left: A sample toolbox from Adobe Photoshop® includes (top to bottom) move tool, marquee tool, lasso, magic wand, crop, slice, spot healing, brush, clone stamp, history brush, eraser, gradient, blur, dodge, type, path selection, rectangle, notes, eyedropper, hand, zoom, stroke fill, background, edit quick mask, screen mode. Right: A sample toolbox from Adobe Illustrator® (top to bottom): selection, direct selection, lasso, pen, type, line segment, rectangle (shape), paintbrush, pencil, rotate, scale, warp, free transform, symbol sprayer, column graph, gradient mesh, gradient, eyedropper, blend, live paint, live paint selection, crop, eraser, hand, default fill and stroke, fill and stroke, color/gradient/stroke, change screen. The fill is solid color, and the open square is the stroke (outline) color. Screen captures from Adobe Illustrator® and Adobe Photoshop®, registered trademarks of Adobe Systems, Inc., in the United States and other countries.

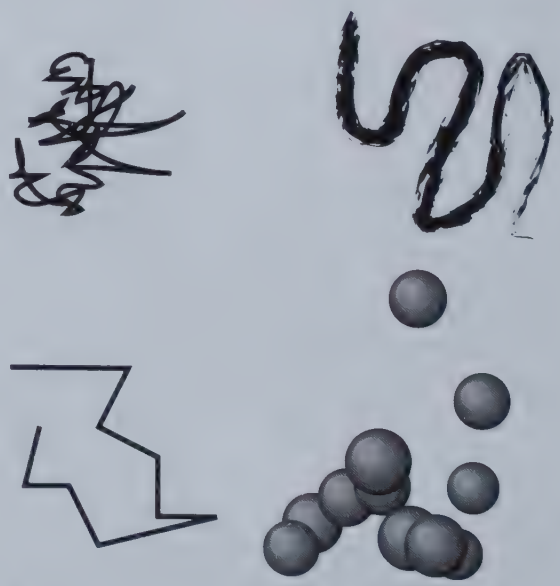


Figure 6–5 Some examples of the use of drawing or painting tools. Clockwise from top left: pencil tool, brush tool, scatter brush, and pen tool. Screen capture from Adobe Illustrator® and Adobe Photoshop®, registered trademarks of Adobe Systems, Inc., in the United States and other countries.

TABLE 6.1
DIGITAL GRAPHIC TOOLS

Tool	Function
Selection	An arrow that allows selection of an item. An item must be selected in order to work on it. A selection box can be dragged around numerous items; shift/click or lasso will allow selection of more than one item.
Pencil	A pencil tool allows drawing of freehand lines or shapes. This requires some control with the mouse or stylus. This tool also has a smooth and path eraser option. Some programs can vary line texture and pressure. Line weight is easily adjusted. Some programs can simulate fine art media such as charcoal, ink, and pastel.
Brush	The brush tool is for freehand drawing and painting. Brush options can control brush size, texture, and shape. Some programs also have options of various transparencies, such as water or dry brush. A scatter brush can repeat a motif or pattern along a painted path. There is usually an airbrush or spray can link with the brush tool, which can spray a fine stipple of color. An art brush will bend an object along a path.
Shape	The shape tool has preset shapes that can be formed by dragging from a corner or the center of the shape. The set shapes include squares, rectangles, ellipses, and circles, as well as a flare and others. Other polygons can be made with a polygon tool. Shapes can also be drawn with the pencil or pen tool.
Eraser	The eraser tool can erase areas down to white or to a previous color area. It can also change or modify an object.
Pen	The pen tool is used for precise straight lines and curves. The curves (Bezier curves) are built from anchor points, which indicate changes in direction. Straight lines can be bent at anchor points, which are clicked to set. The lines made by the pen tool are called paths. They can be open or closed to make shapes. Directional guidelines control the curve of each path.
Type	The type tool allows type to be placed anywhere in the design, inside and out of the object (area type), in a text box, on a path. The type can also be enlarged, distorted, rotated, as with any other object.
Column graph	This tool is for making graphs, pie charts, etc.
Gradient tool	Controls the placement of a gradient inside the shape of the object.
Blend	Creates a blend of characteristics in steps from one shape to another.
Slice (knife)	Tool to trim or cut apart objects.
Gradient mesh tool	Inside a vector shape, a mesh can be manipulated to generate a gradient that suggests a three-dimensional form.
Symbol sprayer	Sprays out selected symbols from graphic objects palettes.
Line	Makes straight line segments as well as arcs, spirals, grids, and rectangular and polar grids.
Fill	The fill tool can fill an area with color, texture, or a gradient. Its icon can be either a paint bucket or an eyedropper. An eyedropper selects a color from an object and applies it to another object.
History brush	Paints with stylized brushstrokes with sources from art history or snapshots.

TABLE 6.2
EDITING TOOLS

Tool	Effect
Zoom	Allows the view to be magnified or moved back from the object.
Lasso	Allows the selection of a group of objects to modify or move.
Blend	Makes shape or color blends between objects.
Scale	Enlarges or shrinks objects. Also reshapes or shears.
Free transform	Allows distortion of objects, including rotation, reflection, shear, and warp options in an intuitive manner.
Hand	Allows the art board to be moved around freely to change the viewing and work areas.
Feathering	Softens transitions between foreground and background objects.
Filters	Encompass a large range of effects that can be used on images. Artistic filters can give an image the effect of traditional art media such as pastel, impasto, brushstroke, etc. There are also larger arrays of textures that can be applied to objects. Various other effects can include distorting, blurring, sharpening, sketching, and pixelating.
Magic wand	Allows the selection of attributes of an object.
Dodge	Affects the surface texture of color of an object by a subtractive process that is more delicate than the eraser tool.
Clone stamp	Allows an object to be cloned and repeated by stamping it.
Spot-healing tools	Edits flaws, red eye in photos.
Crop	Crops down images and photos.
Shape-builder tool	Merges shapes together.
Warp	Blurs objects as well as twirl, pucker, bloat, scallop, crystallize, and wrinkle. This tool acts like a filter effect for individual objects but is more hand controlled.
Rotate	To rotate or reflect an object.
Live paint option	Allows the option of numerous areas to be painted and drawn on the same surface, instead of stacking or layers, more intuitively.

Figure 6–6 Some painting effects that are available. Clockwise from top right: blur, hatch/scribble, extrude, and drop shadow.

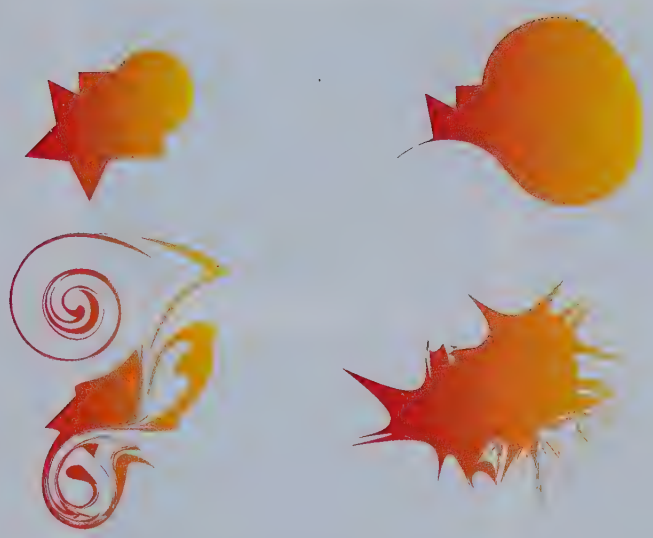


Figure 6–7 Images can be distorted or changed with the warp tool in the toolbox. Clockwise from top left: crystal, bloat, tweak, and twirl.

Figure 6–8 Object Effects. Shapes or other objects can be affected by effects tools (clockwise from top left): original shape, patchwork, scallop, blur, scribble, pointelize, cool breeze, and twirl.

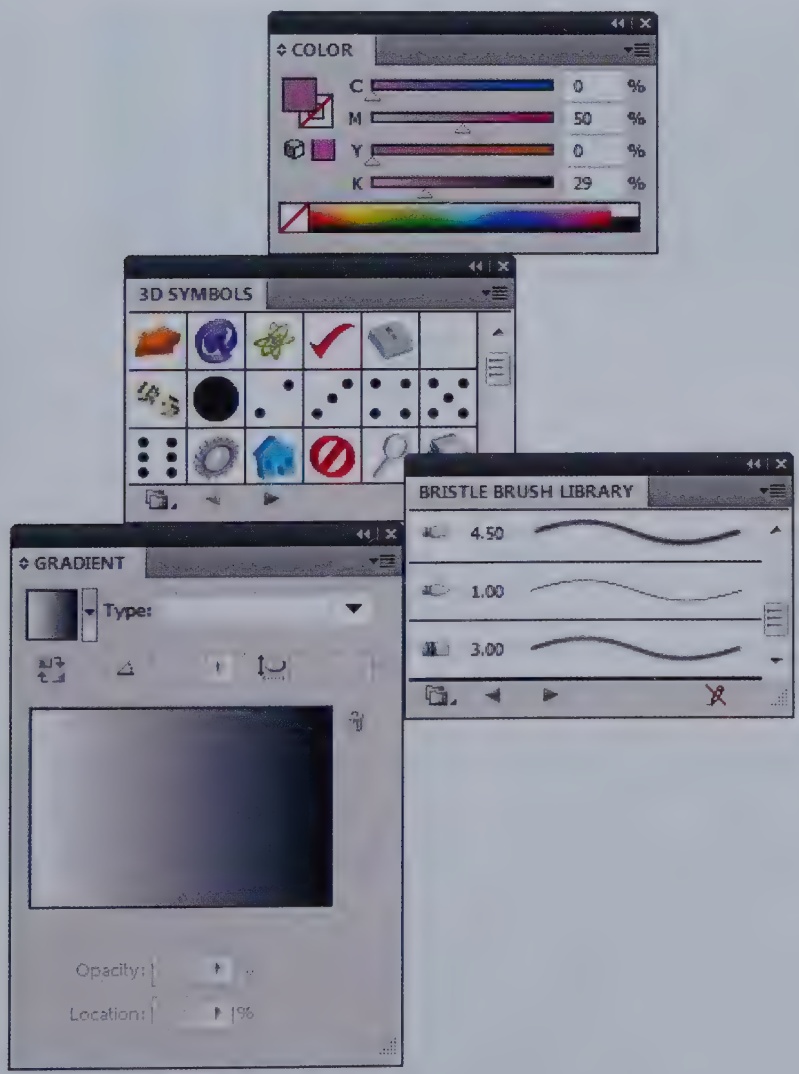


Figure 6–9 A sample array of palettes commonly used in Adobe Illustrator® (from top): brush palette, swatch palette, CMYK palette for mixing colors, symbol palette, and graphic effects palette. Screen capture from Adobe Illustrator® and Adobe Photoshop®, registered trademarks of Adobe Systems, Inc., in the United States and other countries.

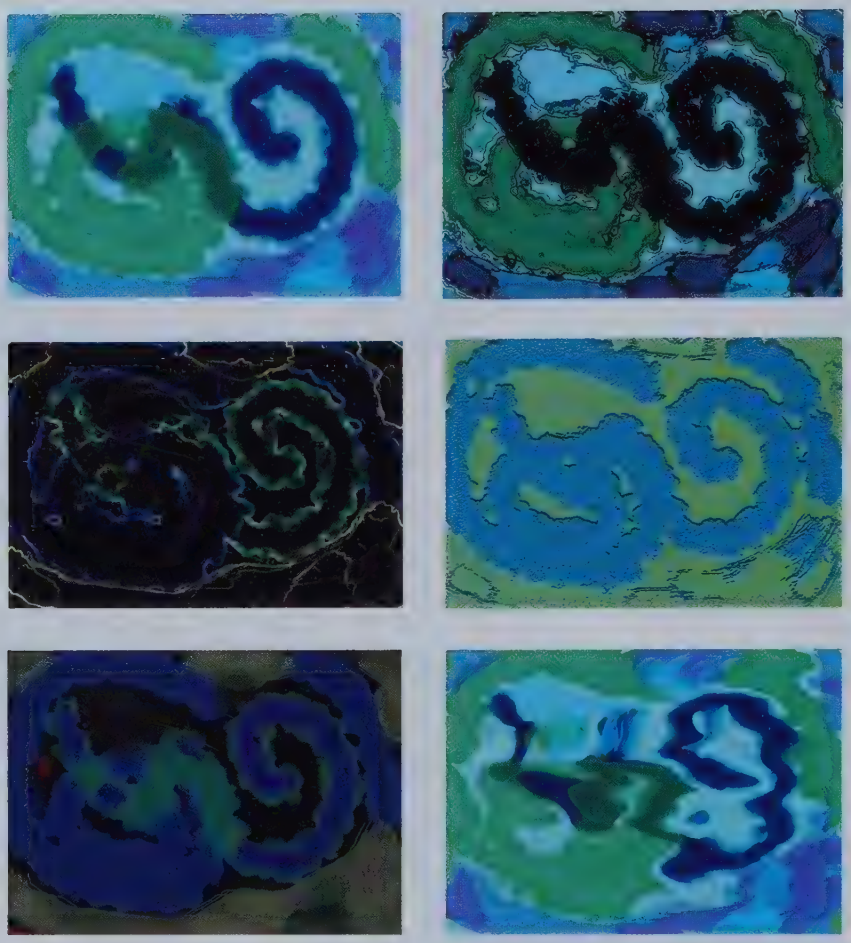


Figure 6–10 Filters can be used to change the character or surface texture of an image. Some filters simulate actual media, while others create more technical effects, such as (clockwise from top left) original image, ink outline, notepaper, liquefy, solarize, and glowing.

Layers

Graphic software functions in layers that can be thought of as clear layers of acetate, each containing a part of the final design. One or more layers are used to create any given artwork; each layer has objects "stacked" in order of their creation. Objects can be moved forward or back in this stacking process or moved from one layer to another by cutting and pasting.

Digital Color

There are several color models available within each graphic program. Each color model should be understood in relationship to its color range, also known as its color space within the CIE gamut, along with its mode of operation. The principal color models are RGB, CMYK, HSB or HSV, Web-safe color, and sometimes a mode called LAB color, which is the computer version of CIE color.

RGB Color The RGB color model is the most common way to encode digital color. A display screen monitor presents color information through light in the additive RGB light color mode. The RGB color model coding is called an RGB color triplet; each set of color information, red, green, and blue, is called a channel. Each channel of standard RGB color has 8 bits of color information, and because there are three colors (RGB), this makes a total of 24-bit color. Each channel is capable of making 0–255 variations on each channel (red, green, and blue). The possible combinations of three sets of 255 provide us with the choice of 16 million colors in the standard 24-bit RGB

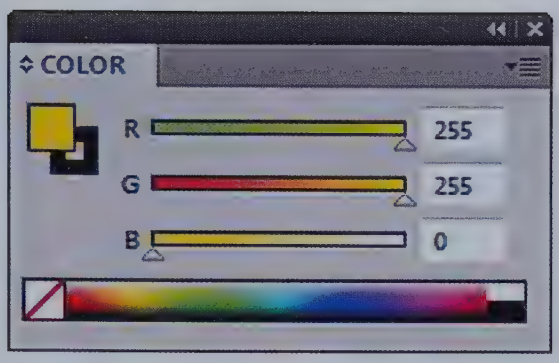


Figure 6–11 RGB Band and Sliders. The RGB slider and spectrum represent the additive color mode of light mixtures seen on the computer screen or from any light-based medium. Screen capture from Adobe Illustrator®, a registered trademark of Adobe Systems, Inc., in the United States and other countries.

model, and much higher in deep color. RGB is also a term for a type of video signal; the three signals of RGB each have their own separate transmission cable.

The RGB color can be selected in several ways. We can select hues from a spectral band or color circle that is displayed in this model. The spectral-hue band has higher-saturation colors in the center, which blend gradually to lighter values of hues on one edge and darker values on the opposite edge. The spectral band allows us to choose colors instinctively. Alternately, there is an option of red, green, and blue in slider format so each channel can be controlled manually in the RGB model. [6.11] As RGB color is parallel to light, the sliders form RGB color mixtures in an additive manner, which may be surprising at first. When all the sliders are pushed up to 100% (255), the RGB colors mix to white light; when all the sliders are set at 0%, the result is black, which is a representation of the absence of light.

RGB colors can be chosen and coded in several ways, represented by a combination of three numbers for each of the three primaries of R, G, and B. Each channel can be thought of as: arithmetic fractional values between 0 and 1.0, or each channel can be coded as percentages, 0%–100%. Another coding for standard 8-bit channel RGB assigns a numerical value between 0 and 255 (0 for none and 255 for 100% on the sliders) for each R, G, and B combination. The principles of additive RGB are consistent with light mixtures as follows in the 8-bit coded list:

R 255 G 255 B 255 (all the primaries at 100%) is white
R 0 G 0 B 0 (all the primaries at 0%) has no light, forming black
R 255 G 0 B 0—only one channel, additive Red
R 0 G 255 B 0—only one channel, additive Green
R 0 G 0 B 255—only one channel, additive Blue
R 0 G 255 B 255—makes the additive secondary—Cyan
R 255 G 0 B 255—makes the additive secondary—Magenta
R 255 G255 B0—makes the additive secondary—Yellow

For example, the RGB code for yellow is R 255 (100%), G255 (100%), B0 (0%), which is consistent with the additive color circle, in which red and green combine to create yellow. The 16-bit per channel color array of Wide Gamut RGB or deep color numerically spans from 0 to 65,535 per channel.

HEXADECIMAL COLOR Another method of coding RGB for HTML for the web is called *hexadecimal color* coding, a complex code based on a 16-unit mathematical combination. HTML uses this six-digit numerical (0–9) and letter code (A–F) to identify specific colors that a designer has chosen; RGB conversion charts to hexadecimal code are readily available. In hexadecimal code each RGB channel is represented by two letters or numbers: White, for example, would be FFFFFF standing for FF = R 255, FF = G255 FF = B255, meaning that all of the RGB primary colors, full strength, add up to white. Yellow in hexadecimal code is FFFF00, meaning FF = Red 255, FF = Green 255, 00 = Blue 0. Alternately, some programs request that RGB values be represented as percentages as they appear on the sliders.

The RGB mode is used for web graphics, art that will be viewed exclusively on the monitor, or for any light-based medium. Scanners use the RGB model like a camera, capturing the red, green, and blue color information from the scanned image. The RGB mode should not be used for the creation of printed material because it forces the computer to convert the RGB color to CMYK mode and color information can thereby be lost. The gamut or range of RGB color is larger than the range of CMYK. When a conversion from RGB to CMYK occurs and a color is out of gamut (range) for printing, the computer warns us that the selected color is not printable. RGB color can also be selected from a color picker box, which shows a chromatic gradation between additive colors.

WEB-SAFE COLOR Web-safe color, also called the web-safe palette or browser-safe palette, is a selection of 216 red, green, and blue additive colors that are common to 8-bit color palettes. The web-safe palette has been largely phased out as the standard of 24-bit color is prevalent on most digital media used to view the web. The web color palette was originally designed so that lower- and higher-bit number display screens would exhibit the same color across varied devices. Using the web palette allows web images to be viewed on 8-bit or higher monitor display screens. Use of web- or browser-safe color is slowly going out of use as fewer display screens have a low-bit depth.

CMYK COLOR MODE CMYK color mode on the computer correlates with subtractive process printing colors. On the display screen, CMYK has sliders that represent percentages of cyan, magenta, yellow, and black, used either singly or in combination. Not every color monitor is able to display pure CMY colors exactly, but using this mode translates perfectly for printed color artwork. The CMYK mode should be used for art that is to be sent out to a printer for publication. A process color swatch book is a vital reference because colors viewed on a screen are different from the final output of printed colors. A screen displays color in an additive mode, forming brilliant luminous color that cannot be exactly emulated in print with process color mixtures. Also, due to unavoidable changes between types of monitor screens, the quality of color varies from screen to screen. Tints in the CMYK mode are formed by low percentages of colors; for example, a 10% magenta is a light tint of magenta. To generate shades, percentages of K (black) can be added to a color. [6.12] Secondary and tertiary colors are mixed by the combinations of CMY: cyan and yellow for green, magenta and yellow for orange, and cyan and magenta for violet. Various percentages of CMY combinations can control both the

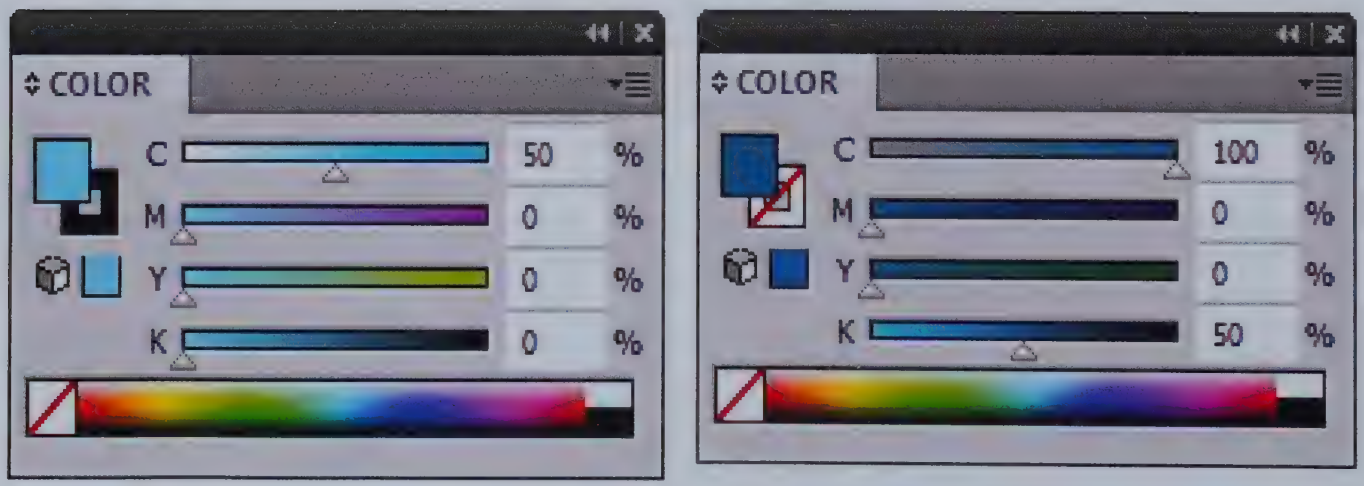


Figure 6–12 CMYK sliders—for a light tint of cyan, the cyan (C) slider is set at 50% cyan, and a shade of cyan is a combination of 100% cyan and 50% black (K). The color appears on the left in the fill color indicator box. The open square is the stroke or outline color, which can also be set to any color. Screen capture from Adobe Illustrator®.

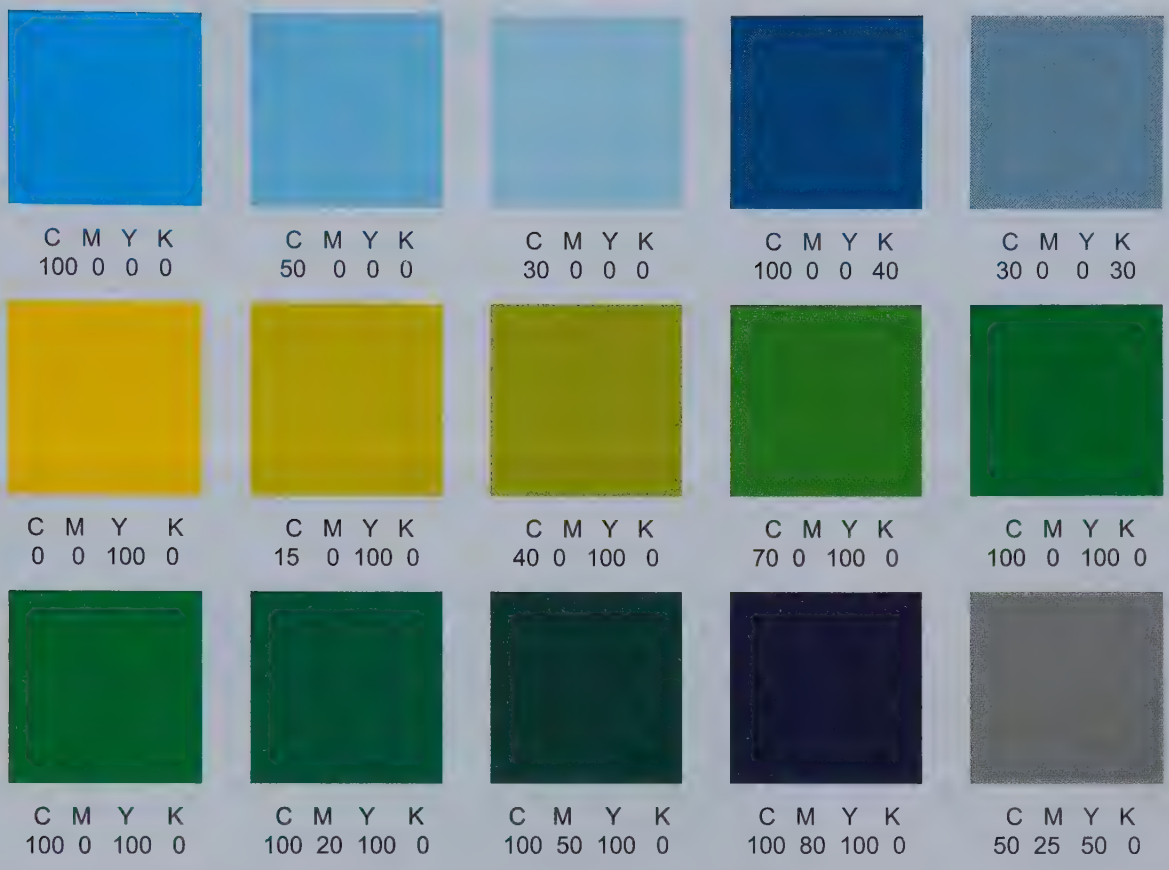


Figure 6–13 CMYK Percentages. The top row shows pure cyan, on the left, with lower percentages to create tints and black added to create shades. The second row shows a chromic gradation from yellow into green by the addition of cyan. The bottom row shows a green with magenta (green's complement) added in increments to mute the green. The last color on the right shows a lower saturation of the muted color by lowering all the CMY percentages.

value and hue cast of a color. [6.13] Neutrals can be formulated from varied percentages of black to make grays: For example, a light gray is 10% black or K, and a dark gray is 80% K. Complements can also be mixed together by manipulation of the sliders. For instance, an orange can be first mixed from yellow and magenta, and then a percentage of cyan may be added to the orange to make lower saturation oranges or blues or chromatic neutrals between the two hues.

Digital artists and designers that work in two modes, between screen display color and commercially printed color, find it necessary to use a color swatch system of some sort, to determine the final result of printed CMYK color. The most commonly used swatch-to-digital color system used in the USA is PANTONE MATCHING SYSTEM®.

HSB or HSV Color Mode A third principal color mode is HSB or HSV color. H regulates hue selection, S controls saturation, and V or B varies value or brightness. HSB is operated by manipulating sliders, a hue box, or a spectral-band display. The HSB color mode directly correlates with the three attributes of color and thus becomes a mechanism for insight into color notation systems. Sliders regulate hue selection, value, and saturation, but all three attributes also operate as a unit. [6.14] For instance, if saturation is set at a low percentage, the whole spectral band in the hue selector appears to be low in saturation. Subtle differences between colors can be chosen from either an enlarged spectral band or a color picker box that displays a gradation between a hue, gray, black,

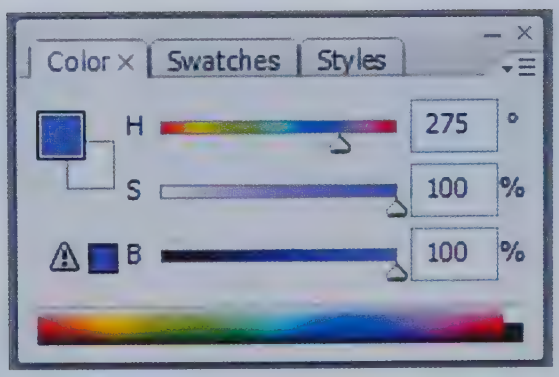


Figure 6–14 HSB sliders are used here to mix a light value violet. H controls hue, S controls saturation level, and V or B controls the value or brilliance of a color. Screen capture from Adobe Illustrator®.

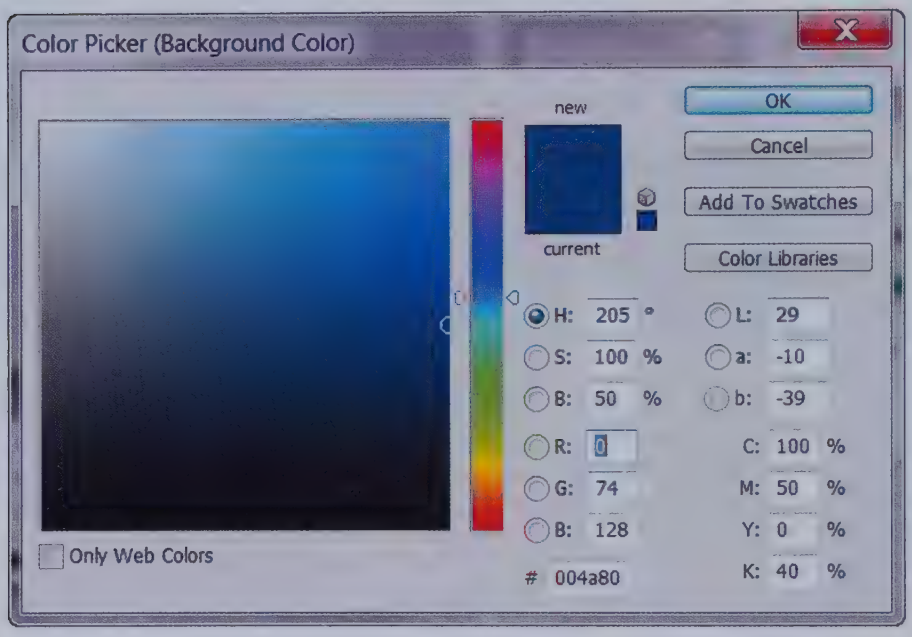


Figure 6–15 HSB color picker can also display many saturations and values of a single hue. A color may be selected from any part of this gradated box. Screen capture from Adobe Illustrator®.

and white. [6.15] HSB color mode is the most instinctive for people who are comfortable with traditional subtractive materials such as paint. However, HSB is not a standardized system; therefore, for printed work, the computer must convert color information into CMYK, and some color information may be lost in this process.

COLOR LIBRARIES Color libraries further expand the color selections contained within graphic programs. Color libraries are large groups of preset colors for color reproduction. Spot colors are used for an exact color match or for color reproductive processes when only one to three colors are desired in addition to black. A printed swatch book is an accurate reference for visualization of how the colors will print (they will appear different on the monitor). Several color libraries may be contained in a single graphic software program, which displays the color swatches on the screen. Most of these color libraries have upward of a thousand colors from which to choose. The PANTONE MATCHING SYSTEM® is the best known of these libraries and is the most commonly used color library in the United States. [6.16] For instance, the Pantone® color library is contained in Adobe Illustrator® in the *color library* drop-down menu in the swatch box—then in *color books*, which have a large selection of commercial swatch book brands such as: TRUMATCH®, TOYO®, FOCOLTONE®, and others. Swatch books

Figure 6–16 Many color libraries are part of graphic software such as the Pantone® library; a small selection of the color library is shown here in swatches. Pantone® is one of the best-known color systems for design, but there are several others. Screen capture from Adobe Illustrator® and Adobe Photoshop®, registered trademarks of Adobe Systems, Inc.

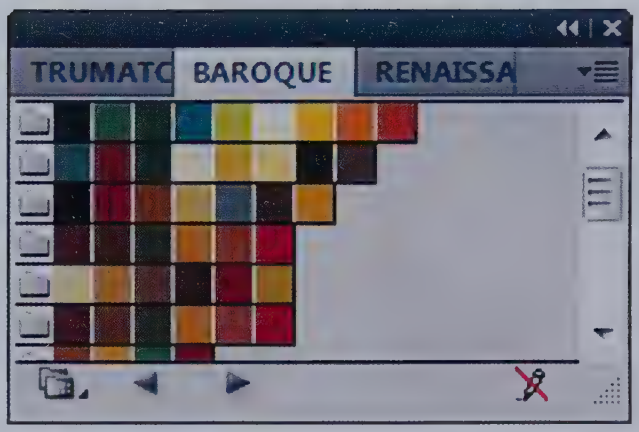


Figure 6–17 Other color libraries are integrated into software, such as groups of colors classified into descriptive thematic categories such as historical, desert, and tropical colors. Screen capture from Adobe Illustrator® and Adobe Photoshop®, registered trademarks of Adobe Systems, Inc.

can be purchased from each color library company and used to choose spot colors or to identify the equivalent CMYK percentages to match each four-color printed result. Even when colors appear to be different from the way they appear on the screen display when compared to the swatch books, they will match perfectly to the swatches when printed. Swatch books have color samples printed on either coated or uncoated paper stock.

Other color libraries are organized into thematic or descriptive color name categories such as pastels, desert colors, sky colors, historical palettes, and so on. These color palettes are user friendly and not as technical as CMYK percentages. [6.17]

Swatch Palette

Most graphic programs have a standard swatch palette that consists of commonly used colors, textures, and gradients. Colors selected from a color library or mixed from any color mode can be dragged and added to the swatch palette to maintain a group of colors while designing. [6.18] Swatch options can be selected to visualize any specific chosen color in a gradient form.

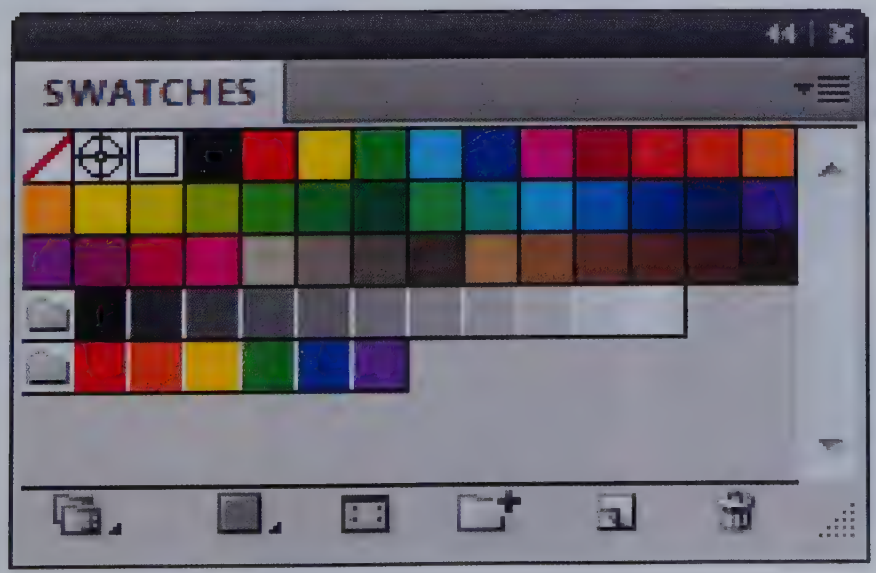


Figure 6–18 The standard default color swatch box or palette can be used for color selection as well as storing other custom colors that are in use. Screen capture from Adobe Illustrator®, a registered trademark of Adobe Systems, Inc.

USING DIGITAL COLOR

Simple design/color studies that are executed with graphic software need not be difficult. Basic exercises are a quick way to execute color studies and to familiarize us with digital software.

Color Theory and Computer Design

It is important to remember that the main concepts of color theory are extremely important in any type of digital design, especially in web design. Color contrasts are the most effective way of differentiating portions of a web page, images, or type against ground. Often, art on the web has inadequate color or value contrast, which makes processing information difficult. The principal types of color contrast that can be controlled for type and ground are value contrast, hue contrast, saturation contrast, and/or cool/warm contrast. The most successful tool to create contrast of type and graphic images with backgrounds is value contrast. [6.19] Contrast can be gauged by reviewing art in a gray scale setting on the display screen. When texture (noise) is used for backgrounds, low color contrasts in the textured areas are most effective. This keeps textures from conflicting with or overwhelming the images or type placed upon them. Examples of low color contrasts are matching values, analogous hues, all low-saturation colors, or all cool colors.

To Pick and Apply Color

Colors can be chosen from any of the aforementioned color models and/or libraries based on what form the designed piece takes: whether printed or viewed on the display monitor. Student color studies can be either printed out or saved on a hard drive or flash drive and viewed on a display monitor.

Figure 6–19 To understand and utilize RGB color contrast for the web, type studies can be created in varied color combinations and textures.

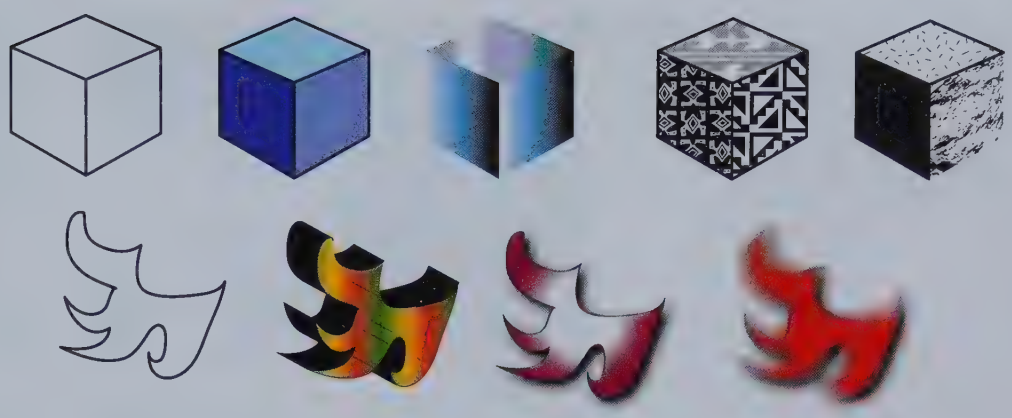


Figure 6–20 Simple modeling of forms, top, drawn with the pen tool, left to right: using flat color, gradients, patterning, and textures. Bottom, shape drawn with the pencil tool, left to right: extruded, with drop shadow and gradient, and blur with drop shadow.

Digital color may be selected either by numerical percentages or by using sliders to choose a color visually. Colors that are used multiple times in a design should be dragged and saved to the swatch palette. Any closed form (fill) or line (stroke) can be easily filled with color by choosing a color and filling the selected object with the paint bucket or eyedropper icon or by simply dragging to or clicking on a color for a selected object. Colors may be swiftly changed as a study is in progress; colors may be immediately reselected and refilled into selected areas. If the stroke (outline) option is set to zero or off, the color will fill a selected shape completely to its edges. There is an enormous advantage to creating color studies digitally because alternate color choices and color combinations can be reviewed with ease.

CREATING FORM WITH VECTOR ART

To create volumetric objects with a vector drawing program, we can start with a line drawing of a closed shape made with a pencil tool, appropriate for freeform shapes, or a pen tool, for straight or curved line work, or build a shape with the preset shape tools, varying them with the shape builder tool. For planar shapes, such as a cube, the shapes can be filled with flat color for planar shapes, or have color gradients on each side, filled with a different pattern on each plane, or use a cutting mask to fill planes with varied brush tool effects, to suggest solidity as shown. Freeform shapes are easy to make; the best approach is to try several methods with preset shape tools combined, using pathfinder to blend, crop, merge, and so on. The pencil tool is a more spontaneous way to produce a closed shape, which then can be extruded, with a filter; have a gradient applied in a radial or lateral manner or use a drop shadow, lighting effects, or blurs to create volume, as shown. [6.20]

Color Adjustments to Photos

A key function of digital color is to color-adjust photos. This can range from simply improving color in personal photos, to artistic effects and use of photographic images in a hybrid form, together with text, flat color, drawn areas, and so on. There are numerous color models for these functions. Most computers are equipped with a photo-editing program that has limited color modes to manipulate color temperature, lightness or brightness, and saturation of color. Often the camera's exposure can be adjusted by heightening or diminishing contrast.

In-depth color adjustment functions in Photoshop® control color and contrast as a separate function on a dialog screen as follows:

TABLE 6.3

PHOTO COLOR ADJUSTMENT FUNCTIONS

- **Brightness – Contrast**—A slider controls each.
- **Levels**—Shows a histogram of each of: Black, white and the RGB channels.
- **Curves**—Shows the histogram in a chart that can be manipulated by a pencil tool.

- **Exposure**—Control, through sliders:
  - *Exposure*—Light to dark like a camera
  - *Offset*—Saturation
  - *Gamma*—Light and dark and color intensity
- **Vibrance**—A slider for Vibrance, a light–dark color control and Saturation, Color Intensity.
- **HSB**—Has three sliders: *Hue* displays a spectral color control, *Saturation*—controls color intensity, and *Lightness*—for light to dark control.
- **Color Balance**—Has CMYK controllers that can be set for shadows, midtones, or highlights.
- **Black and White**—Autochanges a photo to gray scale and also has sliders for RGB and CMY.
- **Photo Filter**—Influences the overall color cast of an image. There are warming filters, cooling filters, and separate spectral colors; the density of each of these can be controlled with a slider.
- **Channel Mixer**—Controls each RGB channel separately through sliders. It also has preset two-color combinations such as Blue, B + W.
- **Invert**—Creates a negative of the image.
- **Posterize**—Makes a segmented, flat color–mapped image of the photo. There is a slider in which lower is more posterized and higher is less posterized, more subtle, and closer to the original image.
- **Threshold**—Converts image to a posterized black and white.
- **Gradient**—Converts a gray-scale image of the original into a prepicked gradient setting, which can also be customized.
- **Selective Color**—Has CMYK sliders for more subtle color tweaking.
- **Shadows/Highlights**—There are slider controls for each of these.
- **Variations**—Display the original next to several premade color adjustments of the image, which can be selected.
- **Desaturate**—Pushes image into gray scale.
- **Match Color**—To match colors to another source image and control luminance, intensity, and fade.
- **Replace Color**—Can control fuzziness and load color swatch for an overall change. There are also HSB slider controls.
- **Equalize**—Is an autoadjust function [6.21].

GRADIENTS Gradients are gradual blends of two or more colors, or a color to a neutral. Gradations blend from left to right, top to bottom, diagonally, or from the center of an object. There are some preset gradients on the swatches palette, but gradients can also be customized. [6.22] A gradient fill is created with the gradient palette by dragging any standard or custom color from the swatch palette to the gradient bar. The gradation itself can be manipulated with the sliders on the bar or on a slider that is on a selected object. The sliders can be rotated, and many colors can be integrated into the gradients. Gradations can be customized by color, direction, and expanse of gradation. [6.23] Gradients are useful in visualizing color blends between a group of colors.

BRUSHES Digital brush options are numerous, and easy to use and customize. Brushes can be chosen from an extensive list of preset types, such watercolor, ink, charcoal, stipple, airbrush, calligraphy, and others. [6.24] Brushes can also spray a group of textures or symbols along a path or be made transparent to any degree. Filters can be applied to brushstrokes to change their character, textures, or other attributes. In a bitmap program such as Photoshop, using brushes is extremely flexible and variable, and there are more filters available because objects are already in raster format, which makes it easier to apply filters.

Using brushes is great way to make optical mixtures and atmospheric or mosaic color effects. Experimentation with various brushes to layer color, create textures, and manipulate filters is a method for making fine patterns that are optical mixtures of two or more colors.

Figure 6–21 Photo color adjustments in Photoshop. Top to bottom, left to right: original photo, threshold, gradient map. Second row: shadows, posterize, invert. Third row: image adjuster, channel mixer, and HSB adjust. See text for complete descriptions of each effect. Courtesy of Becky Koenig.

USING TEXTURES, GRADIENTS, AND PATTERNS

Vector and bitmap programs have numerous preset textures and patterns and textures that can be used "as is" or created or combined more instinctively. Preset textures can be found in Illustrator® under "graphic styles" and applied directly as shown. Objects can also be layered onto these textural backgrounds. Other preset textures can be layered together and combined, such as a graphic scribble style combined with a blob brush with a glow filter applied, each made separately and layered. Several graphic styles can be overlaid together, by making one of them transparent by controlling the opacity slider to 95% or lower. Textures or patterns can also be made by drawing effects, enhanced with filters, or created by picking symbols, using the symbol sprayer to create an overall textural motif, which can be used as a background, with color added/changed or shaped with a clipping mask. [6.25]

TRANSPARENCY The transparency option palette has an opacity slider to control the transparency of a color from 0% opacity (completely clear) to 100% opacity (completely opaque). When using transparent color, new colors are formed when shapes overlap. The objects can be adjusted to top or bottom, which can control how the overlapping

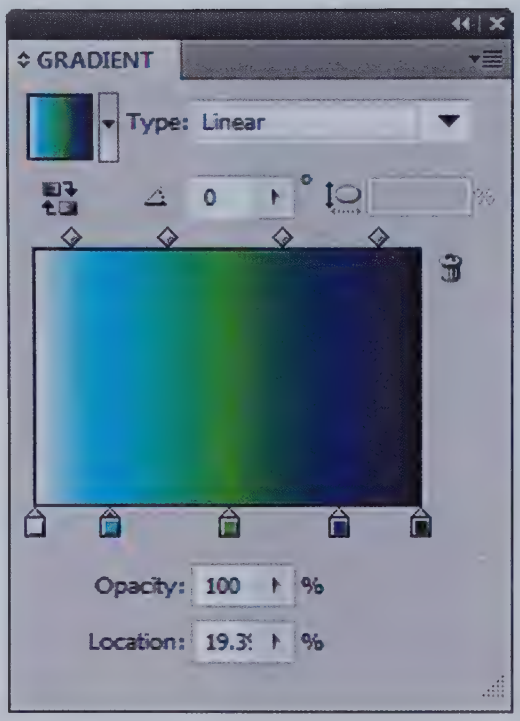


Figure 6–22 Gradients can be customized by dragging any colors to the small squares below the gradient strip. The squares also operate as sliders to modify the gradient. Screen capture from Adobe Illustrator®, a registered trademark of Adobe Systems, Inc.

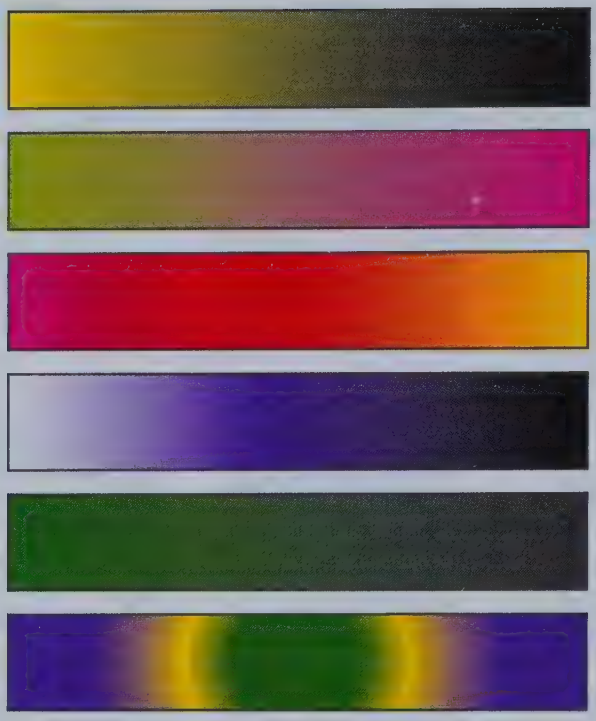


Figure 6–23 Various Gradients. From top to bottom: yellow to black, complementary blend from green to magenta, a chromatic gradation from magenta to red to yellow, a tint/shade gradation of white to violet to black, a tone gradation from green to gray, and a radial gradient of violet to yellow to green.

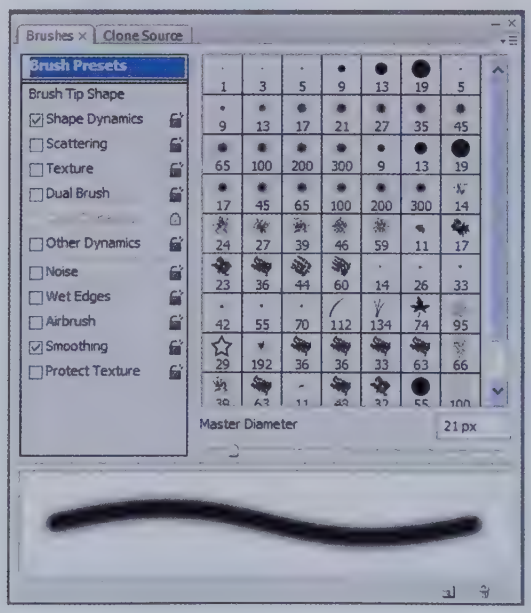


Figure 6–24 Brushes on graphic software have a wide range of functions and visual effects; note the many variables for customizing brushes. Screen capture from Adobe Illustrator® and Adobe Photoshop®, registered trademarks of Adobe Systems, Inc.

color areas mix together to effect the color mix of the transparency. Individual objects or groups of objects can be set for varying transparency percentages.

USING TRANSPARENCIES

Using digital transparencies is similar to making glazes or washes with hands-on materials. The transparency or opacity of electronic color is much more finely controlled, with

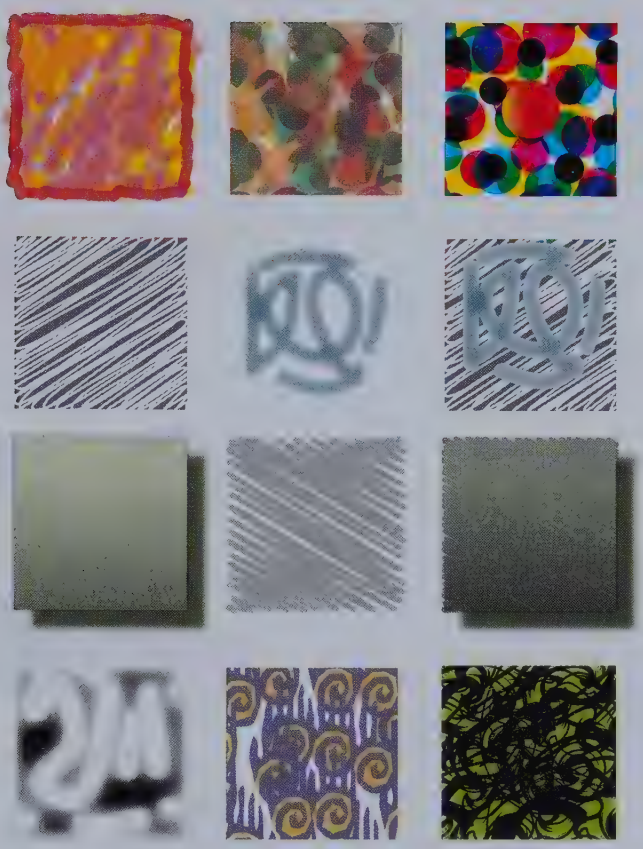


Figure 6–25 Textural effects can be backgrounds or fills for objects. Some samples top to bottom, left to right: top row, first two are graphic effects directly from the palette; top right is an effect with color adjustment and a foreground object. Second row shows a combination of first two effects to create third on right. Third row displays two effects combined by transparency. Fourth row, custom textures created with eraser (left) and two textures made with the symbol sprayer (middle and right).

a slider as above. More subtle effects occur with layers of color, textures, gradients, or patterns. The transparency dialog box also controls effects further, controlling overlay (whether an object is over or under another) and changing blending modes, to make overlapped areas darker or lighter with exclusion, difference, dodge, screen, and so on. Experimentation with opacity levels, layering, and transparency functions can enhance the illusion of transparency in overlapping or glazed design. [6.26]

Computer Color Printing

INK JET PRINTERS When printing from our personal computers, we use an inexpensive ink jet printer. Ink jet printers use the CMYK process colors in cartridges that are applied to the paper by high pressure or heat. Color quality can be improved by printing on glossy photo paper. A dot pattern creates color blends and gradations. High-end ink jet printers can also have pigmented ink (which are actually lightfast pigments *or* dyes), which is much less susceptible to fading over time.

A *giclée* (French for *spray*) printer is a high-end ink jet color printer. It sprays CMYK process inks onto paper in a much slower process that yields richly colored printed materials.

LASER PRINTERS Laser printers are high-resolution printers that use laser technology to define an image. A heat process melts toner powder onto the paper. Laser printers utilize CMYK process color to create colors images either in layers or all at once.

DYE SUBLIMATION PRINTERS Dye sublimation printers convert solid dyes into gases that are then applied as colors onto paper. This process does not use dots as laser and ink jet printers do but forms continuous tones. Dye sublimation printers are a good way to print out high-quality photo images directly from the computer. Most dye sublimation printers use CMYO colors; the black dye from CMYK is eliminated and a clear

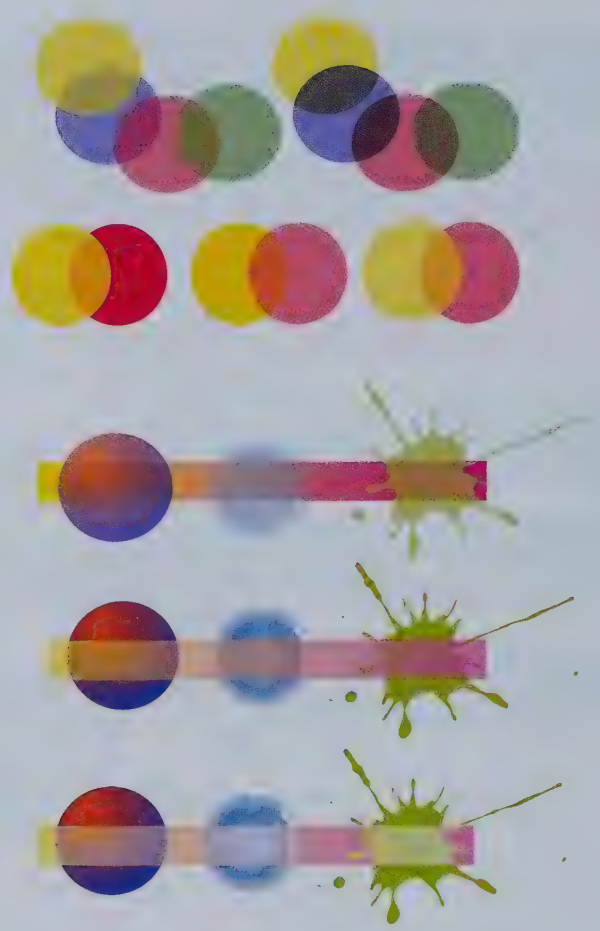


Figure 6–26 Transparency effects, top to bottom: top row shows colors that are all transparent to 60% opacity. The second row shows yellow and red combinations: yellow 60% and red 100% opaque, yellow 100% and red 60%, and both red and yellow set at 60% opacity. The third row shows graphic objects that are transparent over an opaque gradient; the last row reverses the transparency, with the gradient transparent over opaque objects.

overcoating is used instead. This overcoating is a thin laminate that protects the print from discoloration by UV light and makes the print water resistant.

Computer processes uniformly use dyes as their colorants, meaning that the lightfastness of the printed products are dependent on the quality and permanence of the dyes. Some printers are capable of using pigmented inks for permanent art.

COLOR MANAGEMENT

The drawback of digital color is the variation of color gamut spaces from one color model to another, and inconsistencies that may occur between colors on a screen display and printed color. Color management is a way of stabilizing this color variance in order to achieve color consistency between devices: input devices such as digital or video cameras and output devises such as a monitor displays, mobile devices, or printers. CMY and RGB color models are limited by each mode having a number of colors that cannot be reproduced by the other system. For instance, the blue violet we often see on a digital display background cannot be accurately matched on a CMYK ink printer. [6.27] Color variations also occur among different monitors, printers, scanners, and papers.

The primary goal of color management is to control color conversion between devices: cameras, TV screen, printers, offset presses, and so on. Solving color matching problems is a way to achieve color consistency; a color management system or CMS translates color in a precise way between the digital devices. Color management employs an objective manner of defining colors, namely, CIE color, a perceptual color model. The International Color Consortium, ICC, has specific defined standards for a Color Matching Module, CMM. Color monitors can also be calibrated with special software to

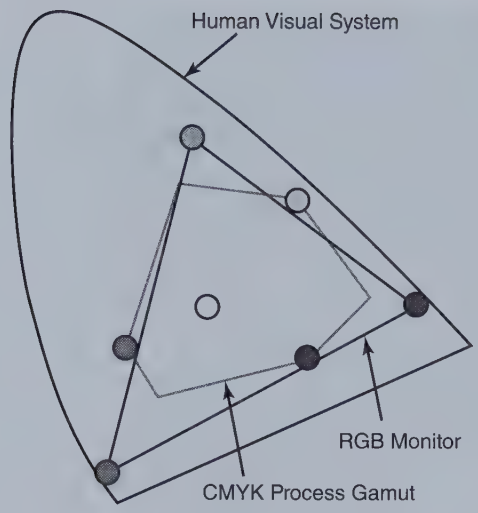


Figure 6–27 Comparative gamuts of RGB and CMYK superimposed upon each other. Note the colors that can be made with CMYK and colors that are not available to RGB. The overlapped areas indicate colors that are common to both modes.

standardize color settings and make screen display colors more accurate. Some graphics programs have color management settings for web graphics and U.S., Japanese, or European prepress.

Color calibration adjusts the colors of one output device to match another. The device calibrated is known as a *calibration source*; the device that serves as a comparison standard is a *calibration target*. The target or the source can be a color space in digital color such as RGB or CMYK, a prepress test print, or color chart like Pantone or Munsell. Colors are calibrated by measuring them in detail by a colorimeter or tristimulus device, a scientific device that provides a very accurate color profile.

There have been substantial improvements in color management, making prepress color checking for accuracy easier through a better color-proofing system and also improved color calibration of display monitors. The color-proofing process can be made speedier by using an in-house, high-quality printer with pigmented inks similar to that at a production press. Digital proofing is another method of more accurate proofing that can be checked before a job goes to press.

Another tool for color consistency is viewing printed color under consistent lighting. Design light booths can be set up for viewing color in balanced light. There is more availability of true-daylight incandescent or combination bulbs that are color balanced between the cooler and warmer color influences of artificial lighting. Adequate and consistent lighting is also helpful in areas where monitors are used in a design studio.

Digital color opens up a huge world of color choices for the artist. An expertise in the color options of each graphic program is the foundation for successful manipulation of digital color.

Activities

Objective: For the student to use and become familiar with the various digital color modes: RGB, CMYK, and HSB. The student will also learn some computer operations by making some simple color studies using fills, blends, and gradients.

The student will explore the combination of analog and digital techniques—to understand the tools of both media and how they intersect.

1. RGB, CYMK, and HSB Experiments

- Use RGB sliders to create white, black, gray, cyan, magenta, and yellow.
- Use the CYMK mode to make red, blue, and green. Use the sliders to make at least five light tints and five shades of different colors. Low percentages make tints, and colors with percentages of black added create shades. Mix complementary colors to make some neutrals.
- From the HSB mode, pick at least two different hues. Manipulate value and intensity to make ten to twelve variations on each hue. Place the colors on the swatches palette.

Figure 6–28 HSB Study. Variations on any two hues are mixed in HSB mode, saved as swatches, and then placed into a pattern.

Use the colors in a grid or another patterned study with twenty or more units. If you use a grid, it may be formatted as 4 × 4 square units, making sixteen squares or 5 × 5 units making twenty-five squares. Repeat colors as desired. Use the rectangle tool and duplicate to make squares or build a pattern with the pen or shape units. Use the grid on your art board as a guideline for placement. [6.28]

2. Color Blends

- Make various hue-to-hue or color-to-color blends using the gradient tool. By dragging pure colors to the gradient bar, you may form a gradient between two to six colors. Using the following color criteria, make the following gradients:
  - Complementary blends.
  - Hue-to-hue blends (use two hues that are difficult to imagine mixed together).
  - Make colors with the CMYK palette and make mixtures between them, such as an orange from magenta and yellow with a violet added (try to conceptualize the percentages to do this).
  - Mixtures between light value and dark value colors
  - Gray and hues to make tonal bars
  - Blends of mixed colors from first activity or hues with white or black [6.23]

Gradient Study

- Make a study of a simple geometric design and fill each part with a gradient. Try using a multicolor gradient and use the lateral and radial styles. Use the slider to control the rate of the color gradation. [6.29]

3. Bezold Studies

- Make a simple pattern with at least five colors. Use shape tools: a pencil tool for freeform shapes or a pen tool for structured shapes (either rectilinear or curvilinear) for parts of

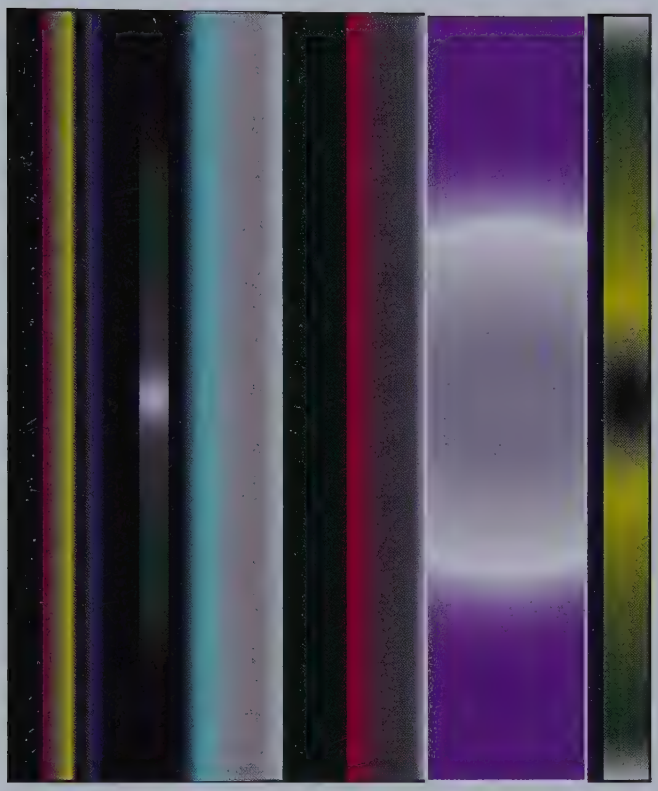


Figure 6–29 Gradient study using gradated colors to create, in which most areas are filled with a gradient.

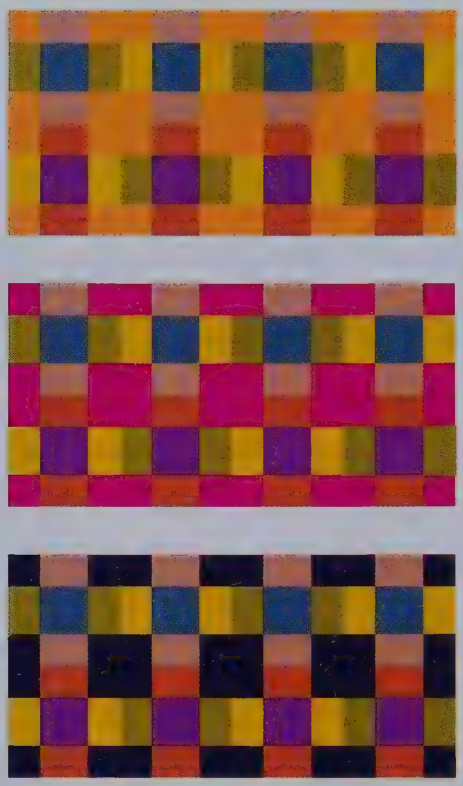


Figure 6–30 Bezold effect studies are fast and simple when made with the computer. Copy and paste an original study and simply change colors and/or gradations to modify the overall appearance of color interaction.

your design. The whole study should be filled with color. Make sure that you save your colors on the swatch palette.

- Duplicate the study on the same art board. Using the same group of colors, change only one color in the design to revise the appearance of all the colors in the study. Make a third design, this time changing one of the colors in the design to a gradient of any color(s). [6.30]

4. Transparency Study

- A study can be made of transparent colors in either a vector or bitmap program, with selected shapes using the shape tool or created shapes using the pencil or pen tool. Shapes can be copied and pasted, scaled to different sizes, and composed with overlapping areas.
- The colors in each shape can be set at approximately 50% transparency, depending on the intensity of each color. Darker hues or colors may not seem to be transparent at 50%, and lighter hues or colors may need to be set to a higher percentage to equalize the colors for a transparent appearance.
- The background color can be set to a neutral color or white, similar to the study in Chapter 4. This will enhance the transparency.
- This study is an easy way to help visualize transparencies and will assist in understanding concepts set forth in Chapter 4. [6.31]

5. Web Color Type Study

- Using a phrase, make several design layouts of type on a ground. The phase can be laid out horizontally, vertically, or diagonally or in a combination of these positions.
- The background should have some type of simple tile motif or texture, all or in part.

Figure 6–31 A transparency study makes use of varied transparency percentages to create the proper color mixes in the overlapped areas.

- Using either the web palette or RGB color, make at least four different color combinations, using some standard harmonies from Chapter 9, or simply concentrate on color contrasts for readability.
- Colors should be also chosen because they are expressive of and sympathetic in relationship to the textual meaning of the phrase.
- This piece may be viewed in gray scale to verify whether value contrasts are adequate to make the text visible. [6.19]

6. Digital Painting

- Make a study using the paint options on your drawing program or painting program.
- Pick five colors for your study and place them on the swatches palette. Use paint effects exclusively to make this study. Vary the brushes; use the airbrush, the blur, and the eraser tools.
- You should also try to apply filters to change the appearance of the piece; however, try to use filters that create painting effects and not ones that look artificial.
- Make a study that is textural and painterly and does not look like it was made on the computer. [6.32]

Analog-Digital Study

- This study explores the connection of analog and digital processes.
- This study can be approached in one of two ways:
  - Start by making a handmade collage of found papers and images that are somewhat textural in nature. Next, either photograph the collage or scan it and turn it into a Photoshop® file. The image can then be painted into—or color adjusted, and so on, to change it yet retain some of its structural characteristics. Alternately, the handmade collage can be recreated in a drawing or painting program.

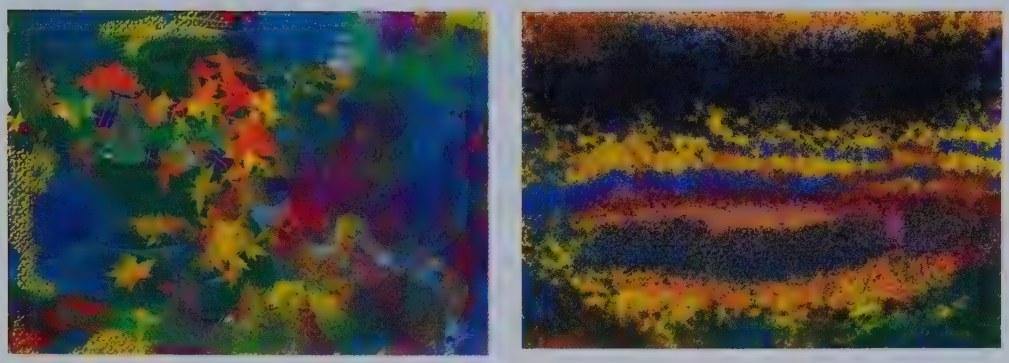


Figure 6–32 A computer painting made with a vector or bitmap program is an experiment with drawing and painting tools, effects, and filters.

- OR: Make a digital painting on any graphic program that you prefer; bitmap is best for this. The painting may be abstract or have images, or be based on a manipulated photograph. Print out and use this image as a starting point of a collage of hand-colored, found colored paper and textures. You also may want to print the digital image out on heavier stock paper and work right into it with paint, collage, and texture.
- The analog and digital studies should be presented next to each other. [6.33]

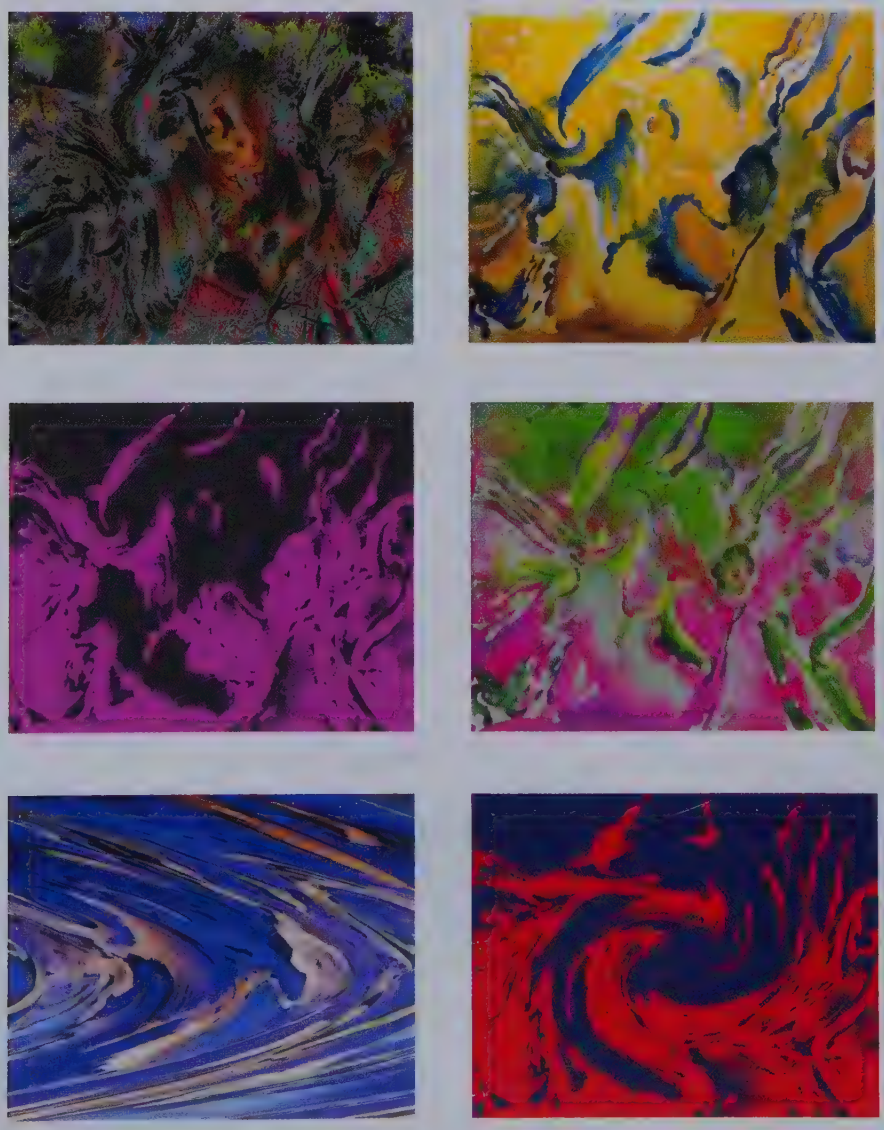


Figure 6–33 Analog Digital Study.

Glossary

Bitmap Images that use pixels to create areas of color on the computer screen; sometimes they are called raster images.

Digital color Color generated by a computer in digital format. It also refers to display color on a computer monitor and the various color modes contained within a graphic program. A computer can produce 16 million colors from which to choose.

HSB or HSV A digital color mode. The H stands for hue, the S for saturation, and the B or V for brightness or value. All three color attributes can be manipulated to produce a huge variety of colors.

Pixel A square unit that subdivides the computer screen is the words *picture* and *element* combined, thus a pixel is a picture element.

RGB Red, green, and blue are the additive primaries of light. RGB also is a color mode used by both the computer monitor and scanner.

Vector Computer graphics programs are based on line drawing defined by math objects called vectors. Vector programs use mathematical locations or points to form lines and shapes.

Part Two
Designing with Color

Chapter 7

The Elements of Design

LEARNING OBJECTIVES

- Understanding the tools of art, the design elements, and their relationship to the concepts of point, line, plane, and volume.
- For the student to be conversant in and use the basic vocabulary of art, the design elements: line, shape, form, space, and texture.
- Understanding the distinct characteristics and variations of each art element through studies and experimentation with digital and analog media.

INTRODUCTION

Design elements, also referred to as *art elements*, are the basic visual building blocks of art. *Form* is the aspect of art or design that is its purely visual component. Within the form or formal realm of art, *design elements* are the visual tools that we manipulate to create two-dimensional and three-dimensional art. The design elements are line, shape, form/volume, space, value, scale, texture, and color; each element has its own unique visual characteristics. The artist or designer picks out appropriate choices from this "toolbox" of art elements in order to express the subject, theme, and/or function of an artwork.

THE ABSTRACT CONCEPTS OF DESIGN

Wassily Kandinsky (1866–1944), an important artist and teacher at the Bauhaus School, in his book entitled *Point and Line to Plane* (1926), organized a basic list of art components that, in turn, establish a foundation for the design elements. Kandinsky identified these four principal components as point, line, plane, and volume, operational in two-dimensional or three-dimensional formats. [7.1] A *point* is defined as either a dot

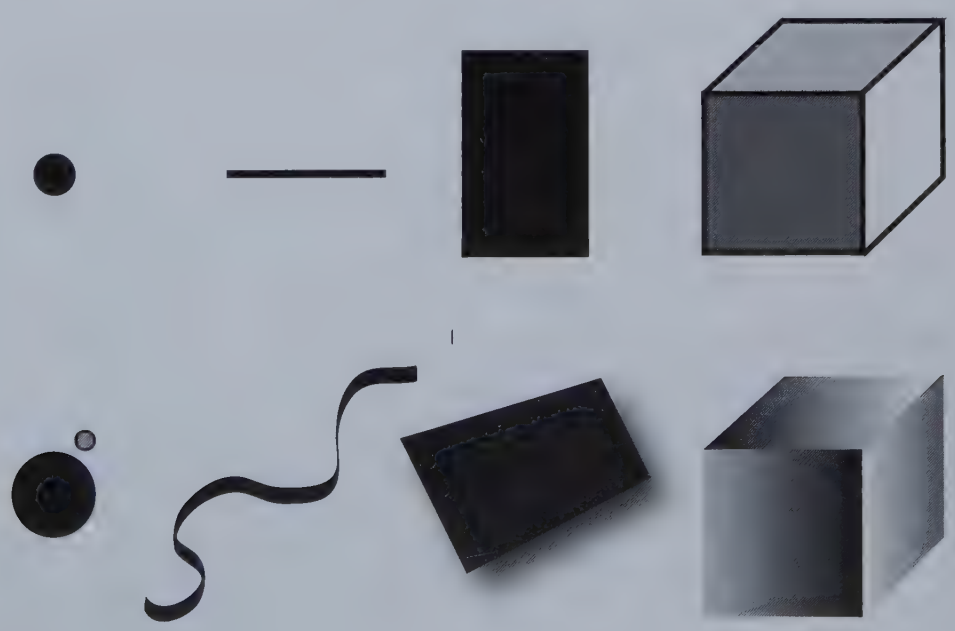


Figure 7–1 The abstract components of design: point, line, plane, and volume.

or mark made by an artist or a location in space. A point may be visible or invisible, of any size; it specifies a particular location within a compositional area. Therefore, in 2D space, a point can be located anywhere in a flat picture surface, including an illusionary space. In 3D art the point is an actual location in a given space. Kandinsky views a *line* as both a connection between two points and a point's movement through space. A line is a 2D or 3D device; either drawn on a flat surface support or an object like a string or wire that moves through an actual 3D space. A plane is a 2D shape made from lines that connect to create a closed form. A plane has height and width, but no breadth or depth and can have any type or configuration or contour. A *plane* is two-dimensional and flat even when it is in a three-dimensional format. A volume is a plane that has been pushed back into or advances forward in space. A *volume* has three dimensions, height, width, and depth. A volume can be either an illusionistic rendering of a form in a two-dimensional space or an actual volumetric mass in a three-dimensional space. The concepts of point, line, plane, and volume are fundamental building blocks of the design elements.

THE PICTURE PLANE

The *picture plane* is a rectangular or square unit that is a fixed entity of art and design, a formal container for two-dimensional composition. By working within the confines of a picture plane, we learn to master compositional forces and comprehend two-dimensional design theory. A picture plane is the compositional window through which we see an artist's vision.

DESIGN ELEMENTS

Line

A *line* is a pathway, the closest distance between two points, the elemental mark, and a moving point. Lines and edges define our visual sense because we identify objects by innately scanning its contour. Line represents the edge of a form, distance, a continuum, and a connector. Line is the trail left by our hand pulling the point of a pencil or pen. The term *linear* refers to line or line quality.

The variables of line are its width, direction, quality, position, and expression. One definition of line is a mark with length greater than its width. However, the width of a line can range from slight and delicate to massive and thick. The direction of a line is an infinite and ever-changing path. We tend to think of lines as straight, but there is also a wide variety of line directions such as: straight, curved, zigzag, meandering, squiggled, angular, massed, spiraling, and overlapping. *Line quality* refers to the texture, media, weight, hand pressure, personality, and speed of a line. [7.2] Word associations can prompt the exploration of line quality. Pairings of linear objects with descriptive adjectives can result in the character of each type of line:

Object	Adjective
Tree branches	Gnarled
Wire	Taut
Leaf veins	Branching
Highway lines	Straight, curved, dotted
Circuitry	Angular
Facial lines	Fine, spreading
Wrinkles in fabric	Undulating, smooth
Yarn	Fuzzy
Barbed wire	Jagged

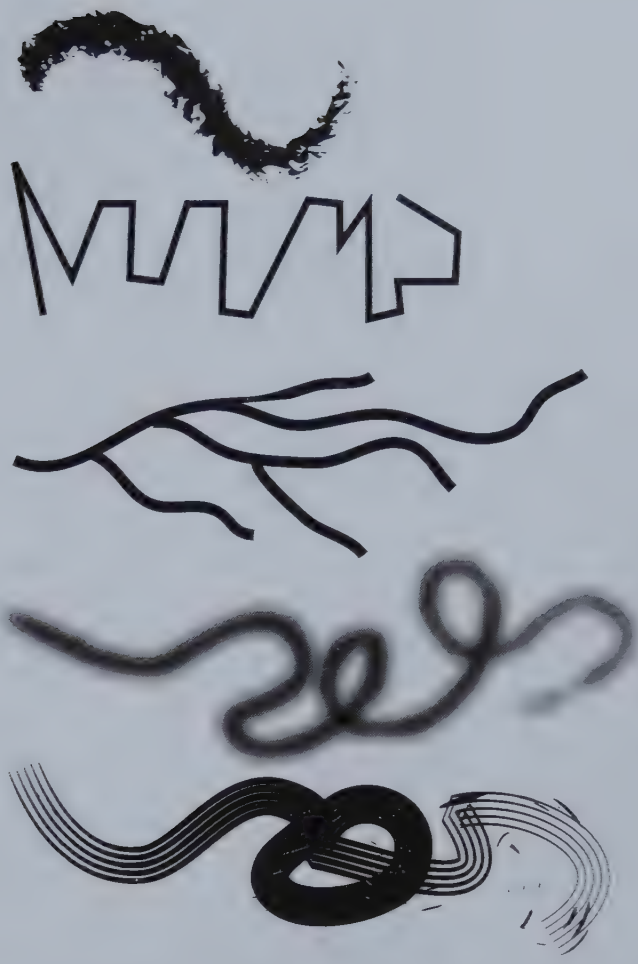


Figure 7–2 Line Direction. Line can vary in any directional path: straight, curved, squiggle, zigzag, scribble, and so on. Line quality varies with hand pressure and media handling.

A similar list links line quality with media to suggest a range of distinctive linear marks:

Tight and delicate—Ink
Bold and heavy—Charcoal
Fast and blended—Charcoal and graphite
High contrast—Black ink with white chalk
Blurred and bled—Ink into water wash
Personal lines—Made from words, letters, shapes, images

Line position is a term that describes the direction of a line in relationship to the picture plane. Horizontal, vertical, and diagonal are the three principal line positions. [7.3] *Vertical* direction suggests height, up and down, north and south. *Horizontal* direction suggests flatness, east and west, the ground, and the horizon. *Diagonal* lines can be in any direction, varying by 360 degrees. A diagonal can be any angle, radiating any direction, or be a stationary 45° angle. Diagonals form a compositional dynamic that indicates movement, speed, rotation, and convergence.

A line can also travel through space three-dimensionally, receding or advancing into the picture space, by convergence or gradation of width. An *actual line* is a physical line in three-dimensional space, for example, a wire or thin piece of wood in a sculpture. An implied line visually attaches to another line as its logical continuum, creating an

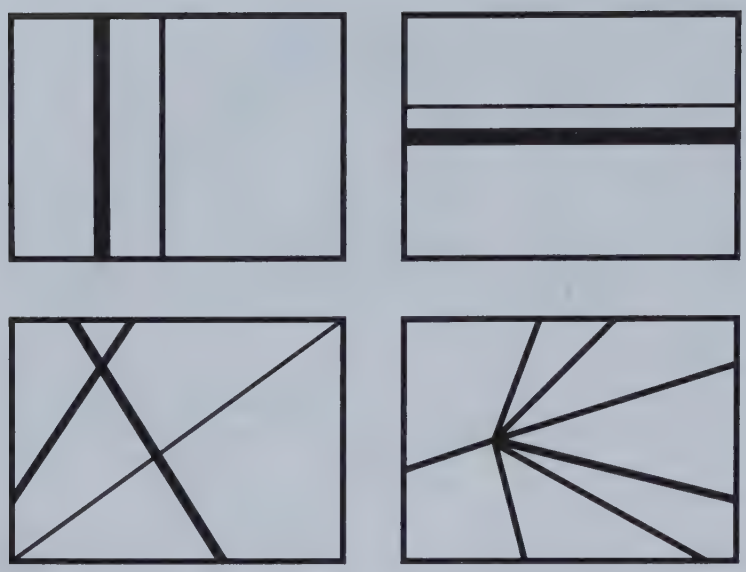


Figure 7–3 Line position refers to its direction in relationship to the picture plane. The main line positions are vertical, horizontal, and diagonal (also shown as "radiating" diagonals).

Figure 7–4 *Line Continuity Study*, student work by Alicia King. Implied line forms a mental and visual connection between the parts of the composition.

invisible connection. [7.4] An implied line is a conceptual line that forms bonds between the parts of a composition.

Shape

When a line connects to or closes upon itself, it produces a shape. A shape is a two-dimensional closed form or plane (Kandinsky). [7.1] A shape can have any contour, height, and width, but no depth. A shape or plane is defined by its edges. It can be designated by an outline or solidified by filling it with a value, a texture, or a color. Shape is almost infinite in its variations.

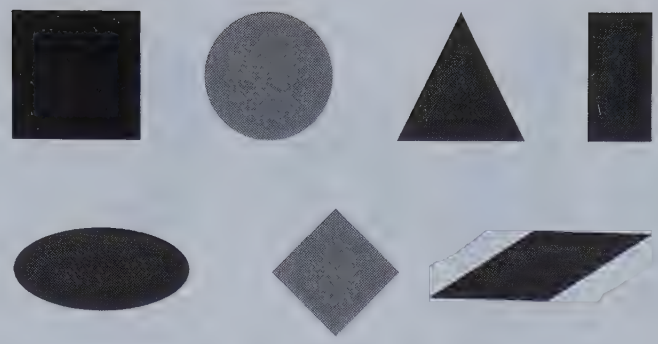


Figure 7–5 Geometric shapes are the standard shape vocabulary: circle, square, triangle, rectangle, oval, diamond, and trapezoid.

There are several categories of shape. Geometric shapes are our standard shape vocabulary: a circle, square, rectangle, ellipse, triangle, diamond, or pentagon. [7.5] Geometric shapes are part of an archetypal shape language and can be building blocks for other types of shapes.

A *rectilinear shape* is characterized by straight edges. Rectilinear shapes have angular structures and may be based on sections of squares, rectangles, triangles, or a combination of ruled lines. [7.6] A *curvilinear shape* is built primarily from curved edges. The contours of a curvilinear shape are derived from circles, ellipses, or freehand curves. [7.7] Curvilinear shapes indicate a sense of movement or continuity.

Art or design is not created in a vacuum; it is continuously derived from our visual experience of the world. Some shapes are reality based: namely organic (nature-made) and mechanical (man-made). *Organic shapes* are those that are inspired by—but not a direct depiction of—nature. [7.8] For example, an organic shape could be derived from a flower, shell, or leaf and synthesized into a simplified shape. *Mechanical or man-made*

Figure 7–6 A rectilinear shape is formed from straight edges or contours.

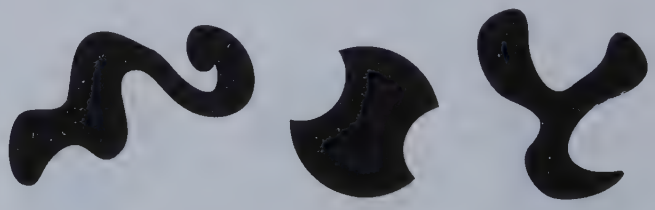


Figure 7–7 Curvilinear shapes are formed from curved edges.

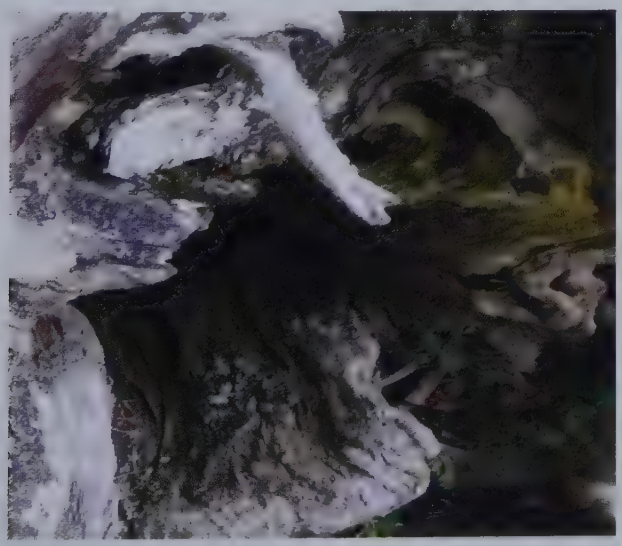


Figure 7–8 Organic shapes are reminiscent of natural forms. Courtesy of Becky Koenig.

Figure 7–9 Man-made or mechanical shapes are those inspired by man-made objects.

Figure 7–10 Symbolic shapes are associated with cultural meanings.

shapes are inspired by man-made objects, technology, architecture, tools, and so on. [7.9] Everyday objects are compelling sources for the invention of shapes.

Symbols are shapes with cultural associations. A *symbolic shape* stands for an idea, such as a cross, a star, a stop sign. [7.10] Symbols have strong associations and communicate specific ideas. The viewer will perceive a thematic message when symbolic shapes are presented in an artwork.

Shapes can be invented and individualized with infinite variety. An *invented shape* is a unique shape formulated by an artist. [7.11] Any of the aforementioned categories of shape may be an inspiration for shape invention. Some students easily develop invented shapes, but others find it difficult to generate their own individualized shapes. Several strategies are effective to facilitate shape invention. *Addition* is a process of overlapping multiple shapes in order to synthesize composite shapes. [7.12] A process of *subtraction* also exploits combinations of overlapping shapes, which are then sheared or subtracted in order to construct new shapes. [7.13] *Intersection* again uses shapes that are overlapped; then, a common residual area is extracted to produce a new shape. [7.14]

Figure 7–11 Invented shapes can be made from any of the shape creation processes or simply by instinct.

Figure 7–12 The additive process forms new invented shapes by overlapping and combining a group of shapes.

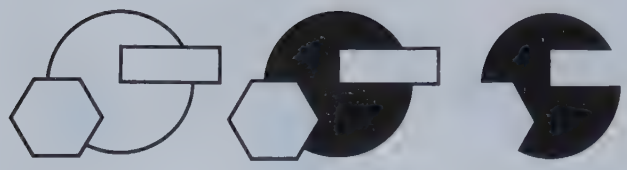
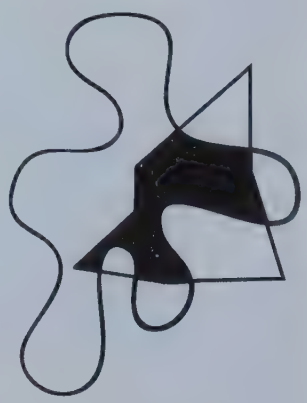


Figure 7–13 The subtractive process uses overlapping to create new shapes. In this case, the overlaps cut away to form a new shape.

Figure 7–14 The process of intersection uses only the area where two or more shapes intersect, which is sometimes called a residual shape.



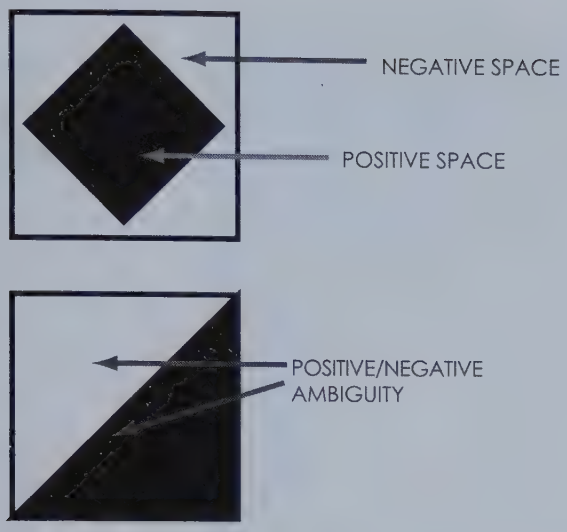


Figure 7–15 The relationship of shape to background. The shape is referred to as the positive space or figure, and the background is called the negative space or ground. When this relationship is unclear, this creates positive/negative ambiguity or figure/ground reversal.

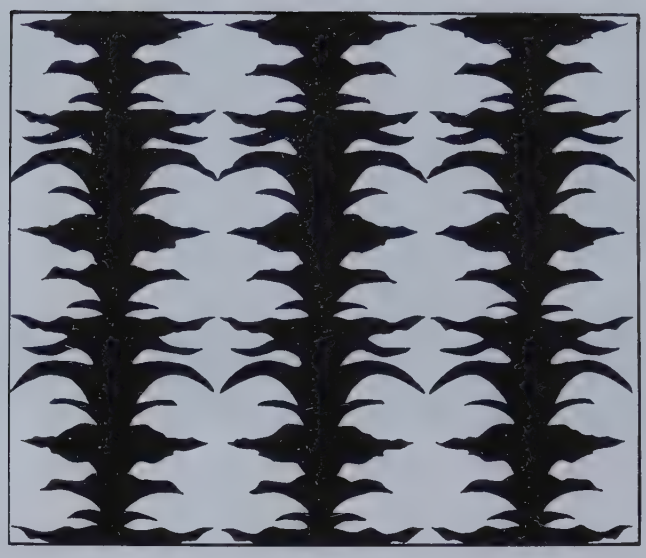


Figure 7–16 Figure/ground reversal occurs in this pattern. Student work by Amberly Strykza. Courtesy of Becky Koenig.

When a shape is placed in a picture space or a three-dimensional space, it occupies more physical area than a line. Thus, there is an interdependent relationship of shape with the space around it in a picture plane, because of the innate mass of shapes. A shape occupies an area called the *positive space* or *figure* in a composition. Space that surrounds a shape is called the *negative space* or *ground.* [7.15] When designing with shape, we need to be sensitive to both positive and negative spaces. The negative space itself can also become a shape. When positive and negative areas of a composition are interchangeable or unclear, this is called either *positive/negative ambiguity* or *figure ground reversal.* [7.16] In this example of figure/ground reversal, our eye perceives the black shapes as a positive space and then shifts to the white areas as the positive space, and back again. A firm understanding of positive/negative ambiguity sensitizes us to the manipulation of space.

Space and Form

Two principal formats of art and design are two-dimensional and three-dimensional structures. Three-dimensional work, such as sculpture or relief, is comprised of *actual* space and form. On a two-dimensional plane, however, space and form are created as an *illusion.* Space in two-dimensional art hearkens back to the Renaissance notion of the picture plane as a window that presents us with a depiction of a three-dimensional world. Our visual experience of the real world forms the guidelines that produce an illusion of space. Gravity, weight, scale, value, perspective, and color all factor into the illusion of three-dimensionality.

FORM The word *form* is a term that is utilized in many contexts and has multiple definitions in art and design. A shape realized in three dimensions is called a *form* and is also known as a *volume.* To represent a convincing spatial illusion on a two-dimensional plane, flat shapes must first be transformed into volumes or forms. A plane or flat shape is changed into a three-dimensional form or volume by the addition of the third dimension of *depth.* A flat rectangular shape can be made into a planar form by adding breadth

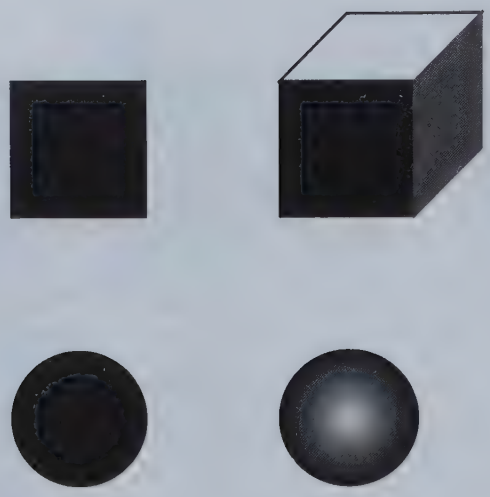


Figure 7–17 A shape is a plane with only two dimensions; a form is a volume with three dimensions or the illusion of three dimensions.

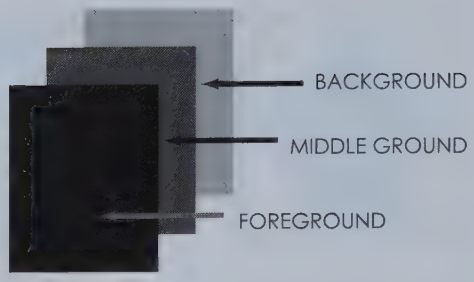


Figure 7–18 The three levels of space can be conceptualized as three parallel planes.

or thickness. A curved or irregular shape acquires volume by gradated values called *modeling.* [7.17]

SPACE Actual or true space is manipulated in three-dimensional art such as sculpture and architecture. It is quite complex to depict what we see and create the *illusion of space* on a two-dimensional plane. The human eye sees distortions in the perception of depth; by understanding and actively using these distortions, we can produce a spatial illusion. Strategies for the formulation of illusionary space range from simple to complex in the following order: overlapping, diminishing size, vertical location, form and modeling, linear perspective, and atmospheric perspective.

The three levels of space are known as foreground, middle ground, and background. The *foreground* includes the objects and spaces closest to the viewer. The *middle ground* is comprised of objects and space that are a medium or middle distance away from the viewer. The *background* consists of the objects that are farthest away in space along with the distant space itself. These spatial levels can be thought of as three parallel planes of glass in layers successively receding from the viewer. [7.18]

Ways to Create Space

The simplest technique for creating space on a two-dimensional plane is *overlapping,* which is the visual placement of one object in front of another. Overlapping or superimposition is a straightforward but extremely effective mode of constructing spatial depth. [7.19]

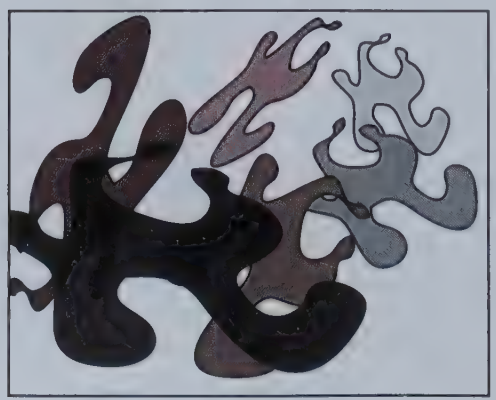


Figure 7–19 Overlapping is the simplest way to indicate a three-dimensional space.

Figure 7–20 Overlapping combined with diminishing scale or size creates a stronger spatial illusion.

Figure 7–21 Vertical location refers to the placement of objects in a lifelike spatial situation. The objects in the foreground are lower in our field of vision; their base lines are lower in the picture plane. Note that this placement is mirrored in the sky area.

Objects that are farther away from us in space seem to recede in size/scale. Because of our sense of size permanence, we instinctively recognize that objects are not actually smaller and that the perception of scale change is an illusion. The illusion of depth in a picture plane can be produced by *diminishing size*; objects become sequentially smaller as they recede into a larger surrounding space. A stronger spatial illusion is established when overlapping is combined with diminishing size. [7.20]

An open space with a horizon line instantly defines a space with both gravity and depth. By adding a horizon line to a picture plane, the bottom section of the composition implies a ground plane, and the area above the horizon line evokes sky. Objects placed in the "ground" area of the picture plane have a sense of gravity and specific location in space. The vertical placement of objects in relationship to a horizon line is called *vertical location.* [7.21] In vertical location each object has a *base line,* which is the base of each object in an illusionary space in relationship to the horizon line. Vertical location emulates what we see in reality; the base lines of objects closer to us are lower in our field of vision. Objects in the middle ground are positioned successively closer to the horizon line as they recede. Background objects are located highest in the picture plane and closest to the horizon line, the farthest point in illusionary space. Objects in the sky area of the picture plane must be correctly placed: larger at the top of the sky, becoming systematically smaller in scale as they are situated lower toward the horizon line. In this way, a similar vertical location strategy is employed in either the ground or sky plane. This strategy is mirrored above and below the horizon line, which represents the farthest point in space. Objects meant to be weightless or floating are not subject to vertical location and can be located anywhere in the picture plane, with diminishing scale to reinforce the illusion.

Linear Perspective

Linear perspective is a system devised during the Renaissance for accurate depiction of space. Perspective is a method whereby volumes systematically become smaller as they recede spatially, replicating the visual illusion of space. Linear perspective is devised from lines and vanishing points that regulate the diminishing sizes we see when objects recede into space. Linear perspective defies logic. In reality, we know that the dimensions of a box, for example, are consistent in height, width, and depth, regardless of the

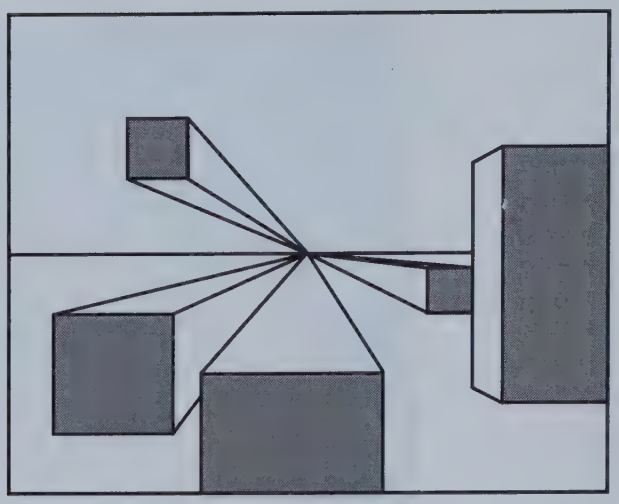


Figure 7–22 In one-point perspective, each object recedes to a single vanishing point that is always located on the horizon/eye level line.

box's location in space. However, the visual scale of objects *seems* to reduce in size toward distant points, which are called *vanishing points.* In one- and two-point perspective, a vanishing point is placed on the horizon line, also known as the eye-level line. The eye-level line represents the viewer's point of view in relationship to objects and the farthest point in space. As objects recede into the background, their edges appear to become closer together and diminish in width. Guidelines for each object converge at vanishing points. One-point perspective is the system used for objects that are located perpendicular to our viewpoint, meaning that a flat surface of the object faces us, perpendicular to our line of sight. [7.22] In one-point perspective, each object's guidelines recede to a single vanishing point, to make, for instance, the front or closest width of a box larger than its rear or farthest dimension.

Two-point perspective presents a view of objects or interiors that are situated at an angle to our vision. For example, a box or building with its corner closest to us is depicted by two-point perspective. [7.23] When an interior is viewed diagonally, it is also shown in two-point perspective. Objects in two-point perspective are defined by two sets of lines receding toward two vanishing points, which are located on the eye-level or horizon line.

Linear perspective can be visualized in two spatial models, either exterior or interior perspective. Exterior perspective guides the depiction of objects in an open space. Exterior views depict either objects seen in a landscape setting or the outside surfaces of architectural objects. Inside or interior perspective guides and depicts an interior view of buildings or rooms in an architectural space.

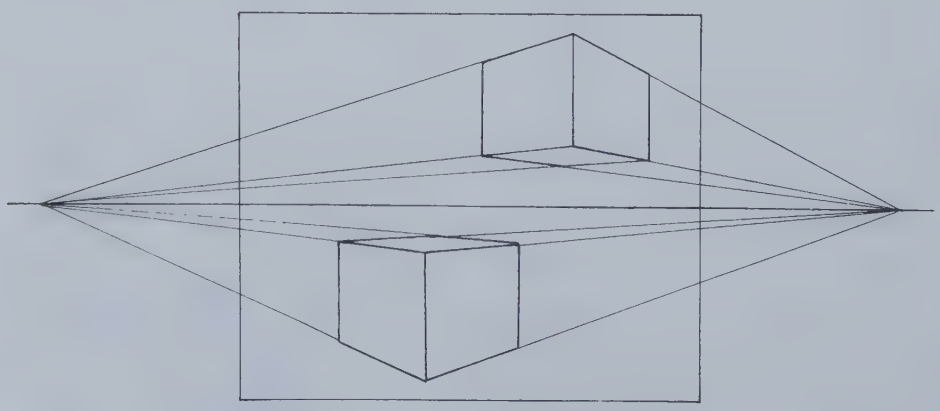


Figure 7–23 In two-point perspective, each object recedes to two vanishing points located on the horizon line.

Figure 7–24 Objects in the extreme foreground enhance a spatial illusion. Student work by Donna Briceland.

ATMOSPHERIC PERSPECTIVE An alternate method for creating space on a two-dimensional plane is atmospheric perspective. The concept of *atmospheric* or *aerial perspective* identifies and utilizes characteristics specific to foreground, middle ground, and background objects in a space. Upon examination of the visual characteristics of real space, we can note that objects in the foreground have more detail, stronger light/dark value contrast, and brighter colors than distant objects. As objects recede into the distance, they visually lose detail and become less distinct. Distant objects appear to have lower value contrast and color saturation as they recede spatially. [10.16] For instance, when viewing distant mountains, they are likely to appear as being lighter, grayer, or bluer than closer mountains. The volume and type of atmosphere (clear, foggy, hazy, etc.) between the distant object and the viewer causes this illusion. For the artist, contrasting color, value, and detail are effective tools for the depiction of illusionary space.

The artist may enhance a three-dimensional illusion by "placing" objects in the extreme foreground. Large-scale objects in the foreground, which seem to obstruct our view, dramatize a spatial illusion. [7.24]

Value

Value, as discussed in Chapter 3, is the series of gradual steps from light to dark between white and black, in either achromatic or chromatic colors. The compositional depiction of space, light, and form is compellingly expressed and enhanced through the manipulation of value. A flat shape gains volume by control of light and dark areas, contrasting values, and gradations. Our sense of a three-dimensional form is essentially "built" from light modulations. A round, curved, nonplanar form is given volume by gradated values. Areas of light, highlight, shadow, core of shadow, and reflected light are all suggested by modulation of values. In 2D art, a curved object can take on the illusion of volume with a play of light across it by smooth, gradual value gradients. In contrast, an illuminated planar, flat-sided volume has abrupt value changes, with light and dark areas defined by the edges of planes. [7.17]

An illusion of spatial depth is most effective when depicted with volumetric, modeled forms like those in real lighting situations. Spatial illusion is further enhanced by a systematic value gradation, which operates in one of these two strategies: dark to light or light to dark. In a dark-to-light approach, the background space is predominantly light (like daylight), and the foreground objects should be dark in value, gradually becoming

Figure 7–25 A Spatial Value Study. Note that the objects seem to recede into space as their values become lighter and have less contrast. Student work by Mimi Fierle.

paler as they recede into space. [7.25] In an alternate method, foreground elements can have defined value contrasts, which gradually become both lighter and less contrasting as they recede into space. An equally forceful spatial illusion can be fashioned with a light-to-dark value system. If the background is very dark (like nighttime), foreground objects should be light and gradually become darker as they recede into the dark space. [7.24] The alternate method for a light-to-dark strategy is to give the foreground objects clear-cut light/dark value contrast, and make the objects gradually become darker and less contrasting as they recede into space.

Value can also be used in a less illusionary, subjective fashion for visual variety and balance, or to highlight an area of interest in a composition. Values that are independent of spatial cues can assist in our understanding of visual dynamics: the way values recede, advance, or draw attention compositionally.

Texture

Texture is the characteristic surface quality of an object. Rough, fuzzy, gooey, and velvety are all words that describe and visually suggest texture. Texture is based on our tactile sense (touch), but we also experience texture visually. Our visual environment informs our sense of texture; we can anticipate how an object's surface will feel solely by visual perception and memory.

Actual or *physical texture* is real texture that is part of a work of art. Chiseled stone, polished metal, or sand added to paint are all examples of actual textures. *Simulated textures* are accurately portrayed textures that create an illusion of being real textured surfaces. An artist's rendering skills of illusionary texture can exactly duplicate a texture visually on a two-dimensional plane.

Textures can also be invented like shape or line. Textures that we invent can be inspired by and derived from visual ideas or descriptive words. Adjectives that describe textures can evoke how they are created: ridged, shiny, cracked, glossy, and so on.

A more experiential approach to texture invention is through media experimentation, which is application of media in unexpected ways. Paints or dyes can be applied

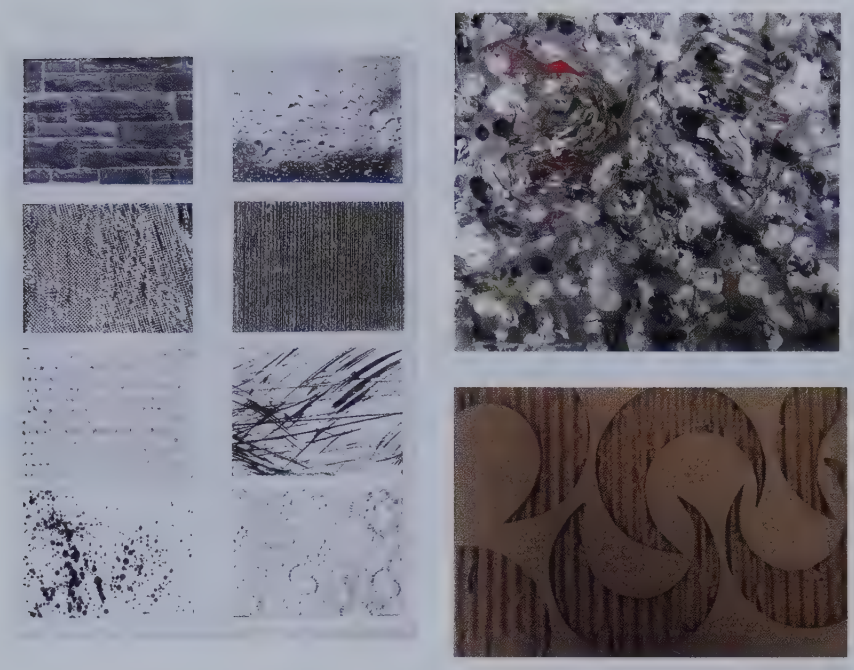


Figure 7–26 Texture experiments are ways to either depict or invent textures. Student work, clockwise from left: Simone Theriault, Satoshi Tsuchiyama, and Andrew Sheffer.

with sponges, toothbrushes, pieces of board, or by using drybrush, impasto, or imprinted objects. Combinations of media can be used. Scraping off or erasing can make visual textures. Actual textures can be made by building up surfaces with crumpled paper, pieces of board, tape, or modeling paste. Additions of textural materials can be made to paint, such as sand and wood shavings. Patterning is a strategy related to texture due to its repeated images, marks, and motifs. [7.26]

Transferred texture is texture that is rubbed and assimilated from a surface. A thin paper stock is laid over a textured surface and then rubbed with a wax crayon, conte crayon, or graphite, which picks up the texture from underneath the paper. A similar effect can be obtained with paint by scraping; this method is called *frottage.* Textures are tools for adding visual diversity, physicality, and complexity to a composition.

The design or art elements are the fundamental visual tools that are central to the process of art creation. Each visual element has individual characteristics and levels of complexity. Art elements are part of formal study as well as a basis for the knowledge of compositional forces.

Activities

Note: All these studies are executed in the achromatic colors of black, white, and gray, so the student can focus solely on the design elements.

1. Line Experiments and Continuity Study

Objective: The student will explore the design elements of line through experimentation with line direction, width, quality, and media.

Media: Black, white, and gray media. Cut papers on 15″ × 20″ illustration board. Leave 2″ to 3″ border and center the composition.

- Make various line experiments with black, white, and gray media (such as ink, graphite pencil, charcoal, gray and white chalks, and black markers) on white paper.

Figure 7–27 Student line continuity study by Priya Patel.

- The experiments should vary widely in direction, line quality, width, and media.
- Using the line experimentation examples that you have made, put together a variety of types of line into a collage.
- The lines should be connected, forming a collaged composition that has single or multiple pathways, using the principle of continuity (see Chapter 8) for unity.
- Try to connect all lines and make smooth transitions between thick and thin lines. The lines should seem to be drawn onto the board. Lines may go "off" the picture plane area. [7.27, 7.4]

2. Invented Shapes

Objective: The student will make a variety of shapes: rectilinear, curvilinear, organic, and invented.

Media: Ink or marker on board.

- Make at least five examples of rectilinear and curvilinear shapes for a vocabulary of shapes to be used in subsequent studies.
- Next, make at least five shapes of your own invention. These shapes can be reminiscent of organic or man-made forms or simply individualized invented shapes. Fill the shapes in with black marker or ink.
- Alternately, shapes can be made, using the combination of several shapes, through addition, subtraction, and intersection. These can be made by hand or digitally with the shape builder tool, or using unite, divide, minus front, minus back, etc., in the pathfinder functions. [7.11] [7.28]

3. Positive/Negative Reversal Pattern

- Using the concept of positive/negative ambiguity, design about ten shapes in 2″ square units. Each unit should have a shape that easily reverses between figure and ground. To increase your success, design these units next to each other. [7.29].
- The shapes can be invented or can be additive or subtractive combinations of several shapes. The units can have equal or unequal amounts of positive and negative space.
- Choose two units to make a pattern, alternating each unit in a grid system. The overall effect should be a unified repetitious structure.
- The pattern may use simple alternation of units, or the units may be mirrored, reversed, or changed in direction. Use tracing paper to aid in this process.

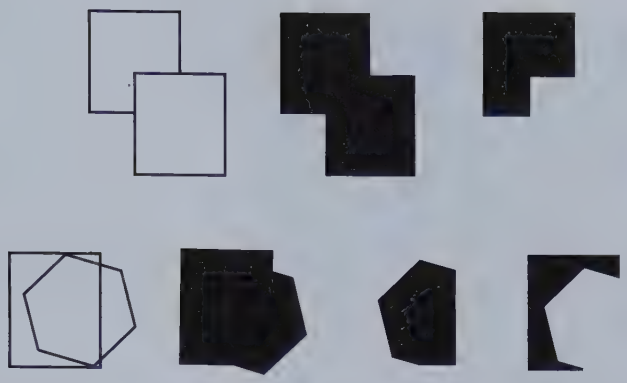


Figure 7–28 Digital shape creation using addition, subtraction, and intersection, through pathfinder tools, top: original shapes, "unite" and "minus front." Bottom: original, "unite," "intersect," and "exclude."

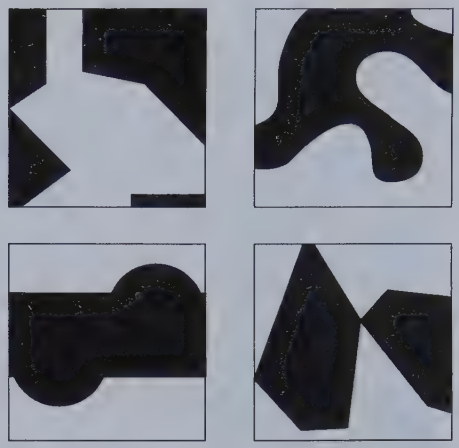


Figure 7–29 Sample pattern units for positive/negative reversal.

- Use a tracing of the pattern to transfer it onto a board. The final pattern should have figure/ground reversal. Overall image size should be 8″ × 10″ to 10″ × 12″ on a larger board, leaving at least a 2" border. Choose size based on what works best for the pattern. [7.30] [7.16]

4. Digital Three-Dimensional Studies

- The student can learn some basics of shapes becoming forms digitally in several ways.
- Invented shapes can be drawn with a pencil or pen tool on the computer.
- After brief vocabularies of these shapes are formed, the student can apply graphic 3D effects (in the graphic effects palette) to each specific shape, which will make them three-dimensional.

Figure 7–30 Positive/negative reversal pattern. Student work by Matthew Marin.

- Other shapes can be defined by gradients, either standard ones from the swatch palette or a gradient that is customized by the student, using a gradient mesh or simply changing the layout of a gradient.
- Another useful tool for giving a flat shape a three-dimensional quality is the use of the "extrude" effect or filter. This can easily give an object a third dimension, whether it is a paintbrush line (stroke) or a shape. The individual object can be moved back and forth in space by using the "arrange command," which determines the placement of an object in the foreground, middle ground, or background.
- The student can thus quickly understand the relationship of volumetric shape, positioning, and scale of objects by the use of flexible changes in a drawing or painting program. [6.20 & 7.21]

5. Value Spatial Study

Objective: To sensitize the student to spatial issues. The student will use value and spatial rules to create a spatial illusion.

Media: Black and white and mixed gray acrylic paint on illustration board. Picture area: approximately 8″ × 11″ to 10″ × 14″, with a 2″ border.

- Make an abstract design to demonstrate the illusion of depth, using linear perspective, overlapping, size contrast, value contrast, and/or atmosphere perspective.
- Use one of the shapes you have invented. Make it into a form by modeling, giving it depth, and making it appear to be a solid volume.
- Set your forms in an illusionary space: an imaginary interior, an open space with a ground and sky, or as floating shapes in space.
- Use several grays, black, and white to emphasize the volume of forms and depth. As forms recede into space, make the values gradually less contrasting and closer to the value of the background. Values may be light in foreground and dark in background or vice versa.
- Plan your composition with value drawings before executing. [7.24, 7.25]

Note: A ten-step gray scale must be completed previous to executing this painting. Use the gray scale as a reference for your final painting.

6. Texture Experiments

Objective: To experiment with media to make simulated, invented, physical, and transferred textures.

- Use black, white, and gray media to make invented textures. Make a list of descriptive words for textures, such as bumpy, jagged, or stippled, to inspire textural variety.
- Carefully make some of the textures into patterns. Make others by experimenting with media. Imprint some objects using various materials dipped into ink, such as string, wire, and sticks.
- Try painting and scraping away layers of acrylic paint. You can make frottage from objects by laying lightweight paper on a textured object, painting with heavy paint, and then immediately scraping away the paper to transfer texture.
- Build actual textures by gluing small objects to a surface and painting them. Physical surfaces can be built up with layers of paper, tape, modeling paste, impasto paint, self-drying clay, foam core that is carved, Styrofoam, and so forth.
- Use paper to make some transferred textures by placing the lightweight paper on textured objects, such as heavy wood grain, coins, and ridged vents, and rub the paper with a graphite stick or a wax crayon. [7.26]

7. Recovered Design (Project Originated by Brian Duffy)

Objective: To develop the picture plane through the use of chance and intuition; to examine the effects of actual and implied texture.

- This project will have an almost urban archaeological quality about it. It is reminiscent of old billboards along the highways that have been neglected and weathered. Layers have been torn away from these billboards, making an interesting abstract composition.

Figure 7–31 *Recovered Design, Texture Study*. Student work by Jennifer Kopra. Courtesy of Becky Koenig.

- On a 15″ × 20″ board, center and rule a 6″ × 9″ picture plane. In this area randomly glue ten to twenty layers of color magazine images with a glue stick. Each layer can have one or several images. Areas of large type with images can also be used. Let the images overlap the edges.
- After several layers are applied, trim the edges, and then continue layering. Avoid too many representational areas.
- When all the layers are completed, use a hand sander, an electric sander, rasps, files, and knives to scrape, tear, sand, and gouge sections of the surface to reveal portions of the layers below.
- As you remove layers, look for relationships that appear and affect the overall composition. You may add collage areas to aid the continuity of the composition.
- Trim composition and mat with white board. [7.31]

Glossary

Art/Design elements The visual tools used to create both two-dimensional and three-dimensional art and design. The design elements are line, shape, space, form, value, scale, texture, and color.

Atmospheric or aerial perspective A type of spatial perspective that is created by emphasizing the differences in the foreground, middle ground, and background, made by atmospheric effects such as higher contrast in foreground, vaguer definition in the background.

Form or volume A shape that is realized in three dimensions is called a *form* or a *volume*.

Line A pathway, the closest distance between two points, a moving point. A line is a mark with length greater than its width.

Linear perspective Lines and vanishing points used to depict the diminishing sizes and recession of objects as they seem to move further away in the picture plane.

Modeling Gradated values that give a shape a sense of volume or form.

Picture plane A given entity of art and design, the rectangle or square that is used to contain the composition.

Plane A shape that has height and width, but no breadth or depth. It is two-dimensional and flat but can have any type of outer contour.

Point Either a dot or a location in space. A point can be visible or invisible and be of any size, but it refers to a particular location or place in a composition.

Shape A two-dimensional closed form or plane. A shape can have any contour, height, and width, but no depth. A shape has mass or area defined by its edges.

Space Actual physical space has three dimensions, height, width, and depth. Three-dimensional space can also be depicted on a two-dimensional format by spatial illusionary devices such as overlapping, diminishing size, vertical location, form and modeling, linear perspective, and atmospheric perspective.

Texture The characteristic surface quality of an object. Texture is related to our tactile sense, but we also experience texture visually.

Value Value simply refers to all the perceptible levels of light and dark from white to black and the lightness or darkness of achromatic or chromatic colors.

Vertical Location The vertical placement of objects in relationship to a horizon line that emphasizes spatial depth.

Volume A plane that has been pushed back or comes forward into space. It has three dimensions: height, width, and depth.

Chapter 8

The Principles of Design

LEARNING OBJECTIVES

- For the student to understand the function of design principles and how each principle addresses a different aspect of compositional forces.
- How the Gestalt principles of similarity, simplicity, continuity, and proximity are interrelated with the principles of design.
- Students should be able to discern the essential design principles of unity and balance from the optional principles of movement, rhythm, and emphasis.
- The design principles and their characteristic differences are explored through in-depth activities.

INTRODUCTION

Design principles are theoretical concepts that guide the order of design elements within a two-dimensional or three-dimensional compositional space. Design process occurs in two major steps. First, there is a selection process of the art elements to be used: line, shape, space, texture, value, and/or color. The second step in the design process is the placement/organization of the chosen design elements in a picture plane, three-dimensional space, or another type of visual structure. The *design process* consists of both selection and location of elements in a piece of art, guided by the compositional principles of design.

Each design principle—unity, balance, emphasis, rhythm, and movement—represents a distinct strategy for constructing visual space. Design principles are guidelines crucial to the *selection*, *placement*, *scale*, and *positioning* of visual elements. Arrangement of art elements, even within the limitations of a two-dimensional picture plane, is a virtually infinite process. Imagine this visual problem: to generate a series of compositions that contain only one design element each—a single black shape on a white ground. The guidelines for this compositional problem are: The shape, a half-circle, may be used only once per composition and can only vary in placement and/or scale. How many different compositions can be formed within these narrow constraints? Figure 8.1 illustrates several compositional options within even a controlled visual structure. [8.1] When the means of visual organization are completely unrestricted, the compositional structure seems to present an infinite, endless series of options that can completely overwhelm an artist or designer with alternatives. When designing with every design element and compositional approach at our disposal, the difficulty is simply in the enormity of choices. How do we go about choosing the best visual placement or structure? How do we evaluate a composition's visual effectiveness? Design principles are thus the strategic tools that provide parameters for the implementation and evaluation of design. Design principles are theories that affect, not constrain, compositional alternatives.

ORDER AND CHAOS

Each area of human knowledge has its own rules, guidelines, theories, and information. Our human nature has a predilection for order, structure, and harmony, prompting us to seek order in the mass of visual information perceived by our eye and processed by our brain. If we cannot perceive a measure of visual organization, we may discern only chaos.

In art and design, there is a fine balance between the order or chaos of visual information. Visual art engages the right side of our brain, which operates through intuition rather than logic. Because of the nature of our intuition, some design decisions are made simply because they "feel" right. The practice of making art through our instincts

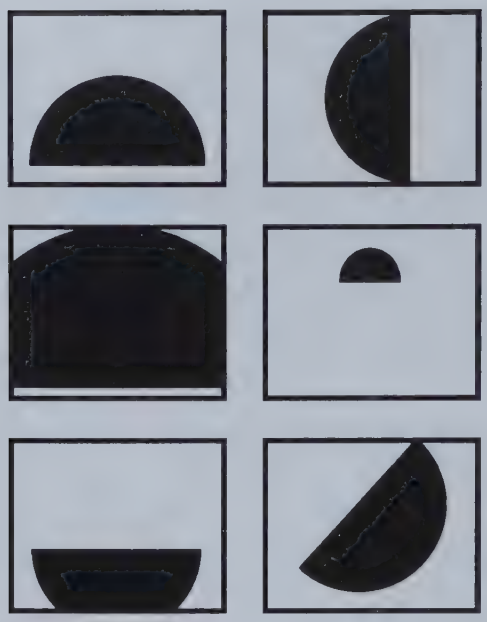


Figure 8–1 Design is about choices and possibilities. Shown here are several compositions made with a shape that has been used just a single time per composition. Only scale and placement have been varied. How many different compositions can be made within these limitations?

should be cultivated. Instinctive art making is unencumbered by rules and actively uses chaos, so to speak. However, artistic instincts that are augmented by concrete knowledge of design theory, visual sophistication, and manual/technological skills insure that we are not merely practicing trial and error experimentation. Compositional order is visually stable, but an excess of order may create mundane, predictable design. In the design process, the emphasis may be placed on orderliness or toward chaos or may be balanced between the two approaches.

GESTALT THEORY IN DESIGN

Gestalt was conceived as interdisciplinary psychological theory with applications in the fields of psychotherapy, memory, and visual perception. Three German psychologists—Max Wertheimer, Kurt Kofka, and Wolfgang Kohler—founded Gestalt theory in 1910. The word *gestalt* is roughly translated from the German to mean configuration. Gestalt theory is based on the idea that the whole of human experience and perception is inseparable and greater than the sum of its parts. Gestalt theorists were interested in both how human beings visually perceive and how they mentally organize information. Gestalt theory has substantial applications to art and design because gestalt entails the study of human perception—the eye as a receptor working in conjunction with the brain. Perception of a visual configuration, pattern, or structure in our visual world is the core of Gestalt theory. Gestalt identifies the impulse that drives our inner search for visual structure and organization.

The analysis of how elements in a visual structure interact to produce a coherent whole is the heart of Gestalt theory. Max Wertheimer wrote, in his essay *Theory of Form* (1923), that our innate need for visual order causes us to perceive elements in cohesive groups. *Similarity* of scale, color, shape, or any commonality of art elements creates these visual groups. Visual groupings cohere because we perceive objects with similar visual characteristics as belonging together. [8.2] Dissimilar objects can be visually grouped simply by their closeness to each other—by being in proximity. We also perceive compositional order through the visual devices of simplicity, called *economy*, and the visual connection of elements in a composition, called *continuity*. According to Gestalt theory, the way that parts of a composition interact together affects our perception of them. Our mind forms visual connections, to logically "fill in the blanks," even

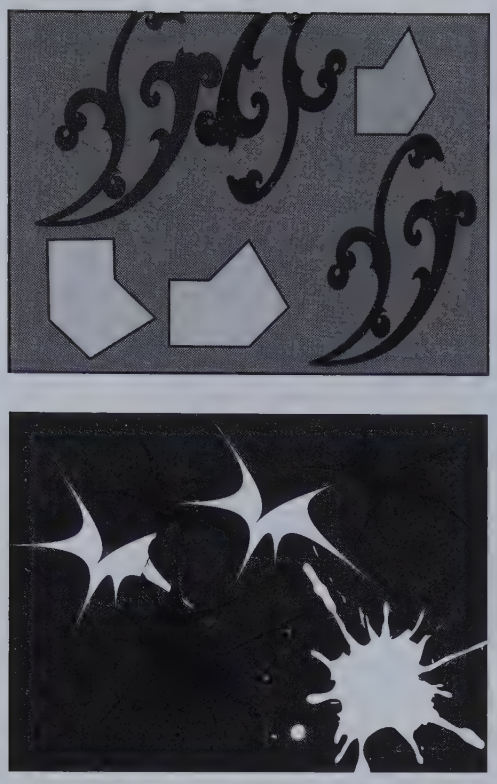


Figure 8–2 According to Gestalt theory, we tend to see objects in logical groups according to different criteria. In the top composition, we may see the rectilinear shapes and the scrolled lines as another. Objects of a similar scale, value, or in proximity may also form groups. In the bottom composition, objects of the same value, particularly the white shapes, form groups.

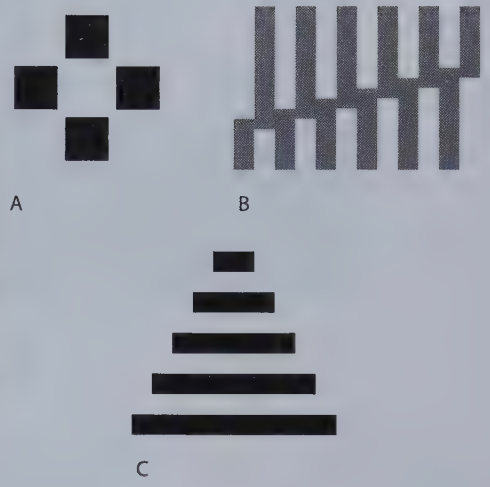


Figure 8–3 Gestalt theory also suggests that we "fill in the blanks" visually when looking at art. Each visual structure can read as (a) four squares or a cross, (b) rectangular shapes in a pattern or a diagonal-based shape, and (c) lines or steps.

with a small amount of visual information. [8.3] Gestalt psychology introduces organizational theories that bolster the principles of design.

DESIGN PRINCIPLE—UNITY

Unity is a design principle that has conceptual parallels to Gestalt theory. The concept of *unity* defines the manner in which a composition holds together, the way that parts of a composition visually cohere. In a unified composition, the interaction of elements produces a configuration so interconnected that it bonds together visually. Unity is also referred to as visual *harmony:* compositional components must harmonize in order to integrate. Unity is regarded as an indispensable design principle because visual harmony is essential for a successful piece of art or design. Compositional elements can be unified via two principal methods: thematic unity or visual unity. *Thematic unity* is utilization of a single coherent idea or theme in a piece of art. For instance, if the theme of an artwork is love of a pet dog, pictures of the dog could be collaged together, along with his leash, pictures of his favorite chew toys, pictures of his favorite people, and a label of his favorite dog food. Although this collage would have thematic unity because a single idea is operational throughout, it may or may not have visual unity. Unity is a method of harmonizing or visually "gluing" together a composition. Visual unity is contingent upon a visually articulate selection and placement of elements in a composition. The following are some simple guidelines that aid in constructing visual unity.

Ways to Create Unity

REPETITION The simplest way to achieve visual unity in a composition is by using the stratagem of repetition. Repetition of any art element or approach enhances cohesion in a design, due to our innate recognition of similar visual elements. When we perceive repetition in design, our mind interprets it as a pattern or configuration. Nature is full of repetitive elements, so we see repetition as a meaningful visual structure. Repetition of visual elements is evident in the natural world—in the patterns of tree branches against the sky or the repeated textural markings on a shell.

To unify a composition, one or more art elements can be repeated—line, form, shape, value, color, or texture. For instance, a shape, such as a triangle, may be repeated to give automatic unity to a design. Design strategies, such as the same position, direction, or scale of an object, can also be repeated in a composition. [8.4] For example, positioning objects in the same direction (such as vertically) will unify otherwise disparate elements in a design. Perfect repetition of art elements produces a configuration called a *pattern,* which repeats the same formation endlessly in any direction. A pattern has perfect unity but inspires limited interest compositionally due to its predictable nature. [7.30]

VARIETY Too much repetition in a design can be visually dull and monotonous. Repetition can be made more visually exciting by pairing it with a design principle called *variety*. *Variety* is the variance or differentiation of an element in a repetitious visual structure. Compositionally, a single visual element such as line may be repeated, but some aspect of the element can be varied—such as diversifying the line width or line direction to trigger interest. Repetition and variety work together in the following examples: repetition of shapes and scale with variety of position, the repetition of position with variety of shape, or the repetition of shape with variety of value and scale. [8.5] A highly repetitious composition increases order; a more diverse composition leans toward chaos. A high degree of variety is more challenging to unify but will appear to be more instinctive. Conversely, a high degree of repetition is easy to unify, but more difficult to make exciting.

SIMILARITY Similarity is a concept that directly corresponds to repetition. According to Gestalt theory, when we perceive *similarity* in a design, our eye picks up an arrangement

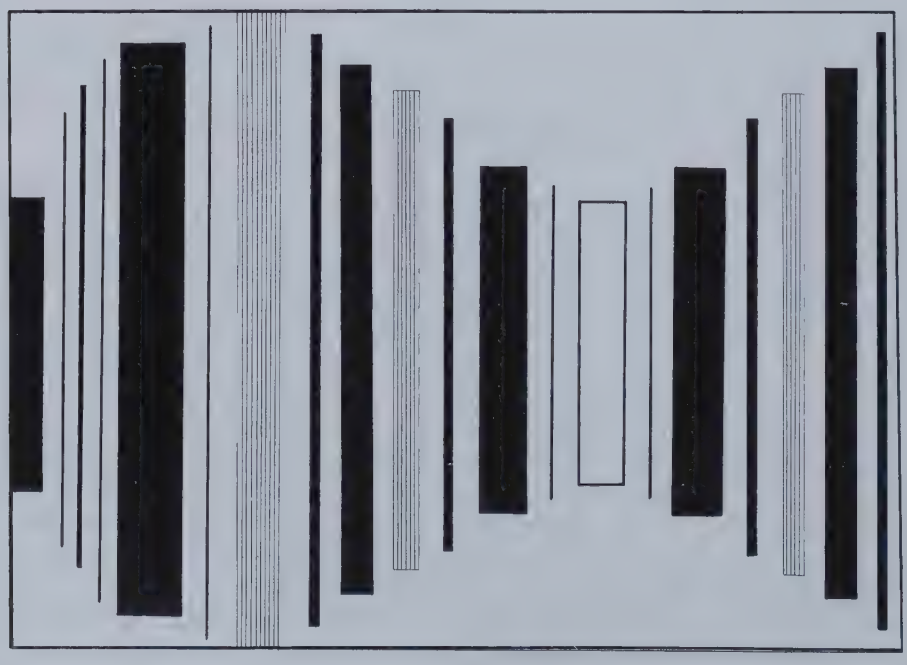


Figure 8–4 Repetition of Direction. In this case verticals visually hold together different line widths. Line position/proximity study. Student work by Mimi Flierle.

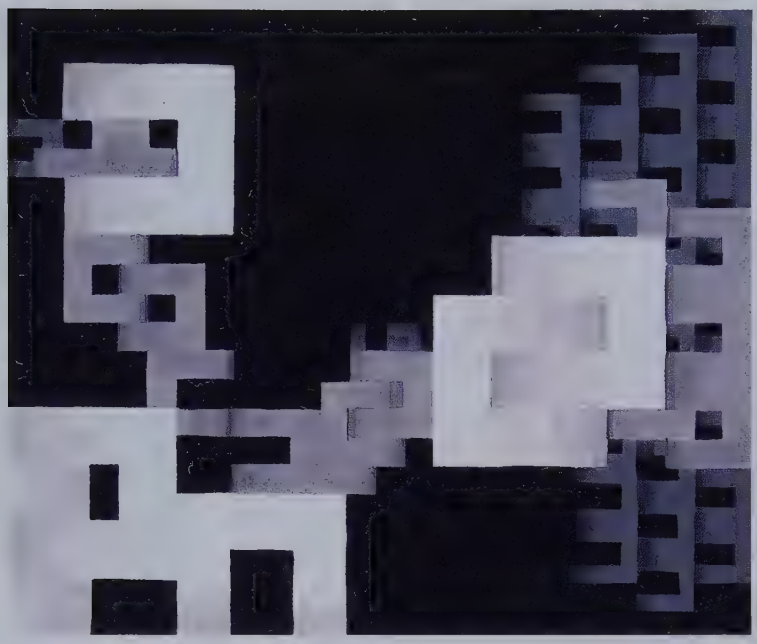


Figure 8–5 This composition has repetition of position and shape, with variety of value and scale. Student work by Liza Palillo. Courtesy of Becky Koenig.

or configuration of related elements. In Figure 8.2, top, squares and marks function together compositionally; however, we may see the squares as a separate grouping from textured marks. In the bottom part of the same example, elements of similar value, even though they vary in shape, also form visual groups. [8.2] The same idea applies to similarity of scale or position. Our eye innately builds a visual unit of elements with common visual characteristics, thus creating compositional unity.

CONTINUITY Another reliable method to attain visual unity is through continuity. *Continuity* or *continuation* is a visual pathway that connects a composition. This pathway can have an actual physical connection between parts or have an inferred relationship (like an implied line) between the elements of a composition. [8.6] Continuity is especially

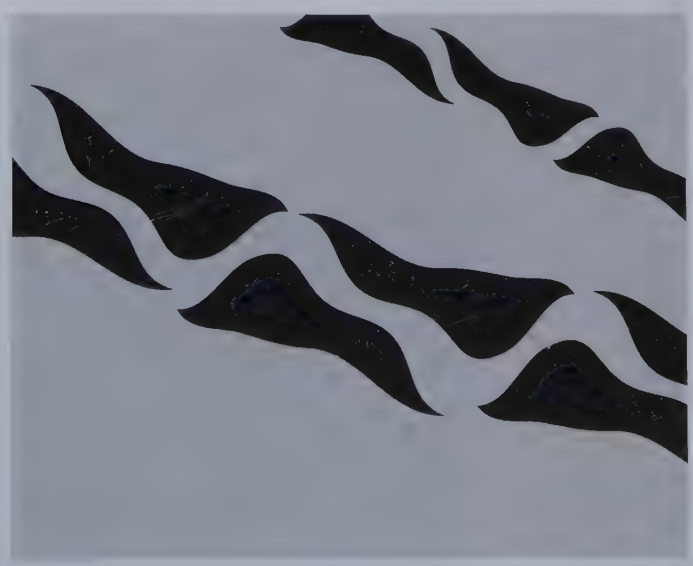


Figure 8–6 Continuity is a visual path through a composition, which serves to unify.

Figure 8–7 Proximity is using the close positioning of elements in artwork to unify and organize a composition. *Shape/Emphasis Study*, student work by Alicia King.

successful in creating connectivity between the elements of a highly diverse or varied composition. A line of continuity provides a "roadmap" that also can direct the viewer through a composition. A continuity route can vary in character—smooth and flowing or jagged and circuitous. Whether employed in an obvious or subtle manner, continuation effectively unites the objects in a visual pathway.

PROXIMITY *Proximity* is a strategy for visually organizing elements by grouping them together. According to this Gestalt concept, even disparate objects can relate visually when they are grouped together. [8.7] Proximity groups can be further defined by surrounding them with negative space. Our eye perceives proximity groupings as cohesive units because of the physical closeness of their positions.

The guidelines for achieving unity can be used either singly or combined together to produce compositional harmony.

ECONOMY

Economy is a design strategy that uses a minimal amount of visual information. Economy is related to the concept of minimalism, in which "less is more" visually applying the Gestalt concept of simplicity. Extreme economy of means or elements sets up a compositional challenge for the artist. Economical compositions are often visually arresting and bold due to their extreme simplicity and clarity of thought. [8.8] Economy is a valuable technique of paring down the design process to its barest elements.

DESIGN PRINCIPLE—EMPHASIS

The design principle of *emphasis*, also called *focal point*, pertains to forming a specific region of visual interest in a composition. Unlike unity, a focal point is not essential to effective design. However, an artist may choose to emphasize a specific portion of artwork to enhance a particular image or theme. To establish an area of emphasis/focal point, a composition must provide the viewer with visual clues to direct the eye to a particular area of focus. Numerous points of emphasis in a composition can all be of equal

Figure 8–8 Economy is the use of a minimal number of elements to structure a composition.

importance, or one point can be primary, one secondary, and so on, in a type of visual hierarchy.

Ways to Create Emphasis

CONTRAST The simplest way to create emphasis in design is to cultivate some type of visual *contrast.* Our eye naturally focuses on whatever portion of a composition stands out visually as different, unexpected, or contrasting with the overall composition. For maximum effectiveness, a contrast should be in some type of visual opposition to its surrounding environment. Any art element may be deliberately contrasted with its surroundings—line, shape, color, form, texture, and so on. For example, a dark shape may contrast a light environment, a textured area can oppose an area of solid shapes, a three-dimensional form contrasts to an environment of flat shapes, or a flat shape contrasts a three-dimensional environment. [8.9] Design strategies such as scale, position, and complexity can also be manipulated for contrast to indicate a focal point. For

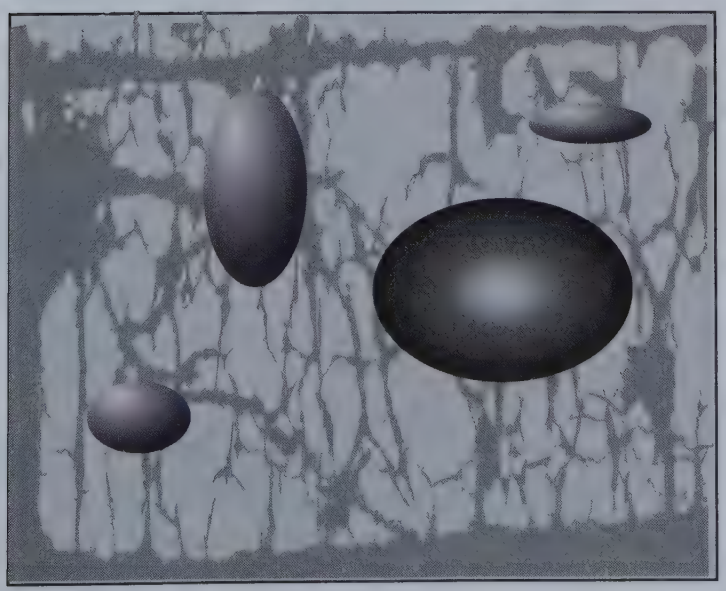


Figure 8–9 Emphasis established by contrasting line with form. Our eye goes to the textured mark because it contrasts with the forms of the composition.

Figure 8–10 An anomaly in design is an unexpected element that stands out as a departure from the overall visual structure.

example, a light value form with complexity will contrast with a darker and simpler environment, a large simple form will stand out in an environment of complex textures, or a diagonal placement of a dark shape will stand out against an environment of light vertical lines. An area of visual contrast is also known as an *anomaly,* which is an unexpected departure from a dominant visual structure. [8.10] An anomaly attracts attention because of its unforeseen nature in the overall strategy of a design.

ISOLATION The strategy of isolation is a fundamental method of constructing a focal point. *Isolation* is produced by physically separating a specific area or object from the remainder of the composition, thus forming a point of emphasis. A compositional object may be isolated by a large area of negative space: set adrift, so to speak. [8.11] In this

Figure 8–11 Emphasis is created by isolation. *Shape/Emphasis Study*, student work by Allyson Carreon. Courtesy of Becky Koenig.

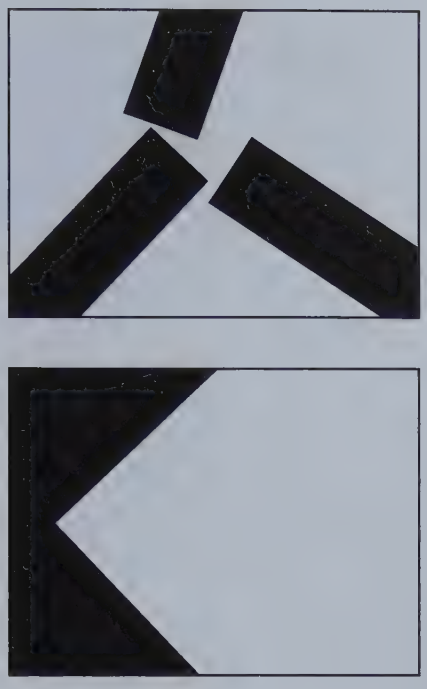


Figure 8–12 The directional force in a composition can create emphasis and tension points.

type of isolation, negative space operates as a buffer, keeping the isolated element(s) from interacting with the remainder of the composition. A second method of isolation is to confine an object within a shape or particular area, referred to as *enclosure,* which is akin to circling or outlining the object. [8.7] Isolation by manipulation of negative space or enclosure effectively produces a visual point of emphasis in a composition.

DIRECTION *Direction* is the manipulation of the directional forces of shape, line, position, or form to generate an area of emphasis. Direction, a concept directly related to continuity, exploits the visual force of implied lines to guide the eye to specific point(s) of compositional interest. Our eye can be directed to a point of emphasis in either an obvious or subtle fashion. Elements that are nearly touching in a design form visual tension, which can effectively direct attention toward a specific point of focus in a composition.

A focal point may be located anywhere within a picture plane. However, it can be risky to position a point of emphasis directly on the edge of or close to a corner of the picture plane. Either of these placements may cause a balance problem or inadvertently lead the viewer's eye out of the picture plane. Conversely, a focal point need not be placed consistently in the center of the composition. [8.12] The center of a picture plane is highly stable, but it also can be an overly predictable position for a focal point. Risk taking is integral to good design, so the locations of focal points should be flexible.

Value can also be positioned in an arbitrary fashion for variety or balance, or to highlight an area of interest in a composition. Placing values arbitrarily will help us understand which values recede, advance, or draw our attention in a compositional context.

DESIGN PRINCIPLE—BALANCE

Balance is the equal distribution of visual weight in a piece of art. The design principle of balance is a vital component of any work of art. We all have an inner sense of visual balance, weight, and symmetry because of the movement and symmetry of our bodies. We are aware of our own balance and weight during everyday activities—walking, riding bicycles, carrying heavy objects, and so on. To achieve balance in design, we are working with the concept of visual weight. Objects in 3D art have actual weight or suggested weight. *Visual weight* is the relative visual importance of art elements and their

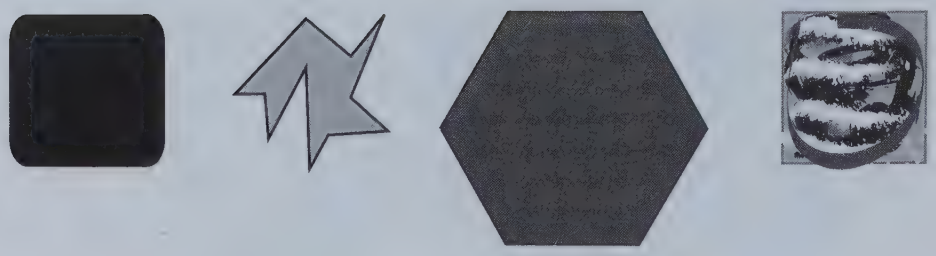


Figure 8–13 Elements with visual weight include those with dark value, complexity, large scale, and texture.

characteristics in a composition. Art elements or art concepts are not equal but have disparate visual weights. Complexity, texture, dark value, and large scale all have innate visual weight. [8.13] Contrasts attract attention and have visual weight, like strong contrasts in value, scale, position, and/or depth. [8.14] Art elements that contrast or in some way oppose their visual environments in some way, such as a textured element within a smooth area, a dark element in a light environment, and a modeled form in a flat space, all have visual weight.

An *axis* can be placed in the center of the picture plane to divide the composition into two halves, to analyze the balance in a picture plane. A picture plane subdivided by an invisible axis vertically, horizontally, or diagonally helps us to gauge visual weight on both sides of the axis.

Symmetry

Symmetry is formal balance, or perfect balance, vertically, horizontally, or diagonally on either side of the central axis of a composition. [8.15] In a symmetrical composition, elements on each side of the central axis are perfectly equal. When compositional elements are mirrored on either side of the axis, the axis is called the *line of symmetry,* which is the center of formal balance in either two-dimensional or three-dimensional design. We all have an inner sense of symmetry, as our bodies are essentially symmetrical in form, which makes symmetry feel "right" as perfect balance. However, symmetry can be static and predictable if habitually applied as a compositional structure; it is a stable visual structure that yields balance easily. [8.16]

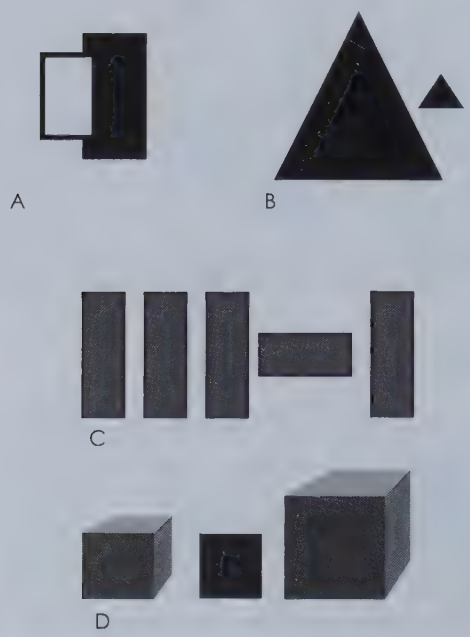


Figure 8–14 Contrasting elements carry visual weight. As shown here: (a) value contrast, (b) scale contrast, (c) position contrast, and (d) shape/form contrast.

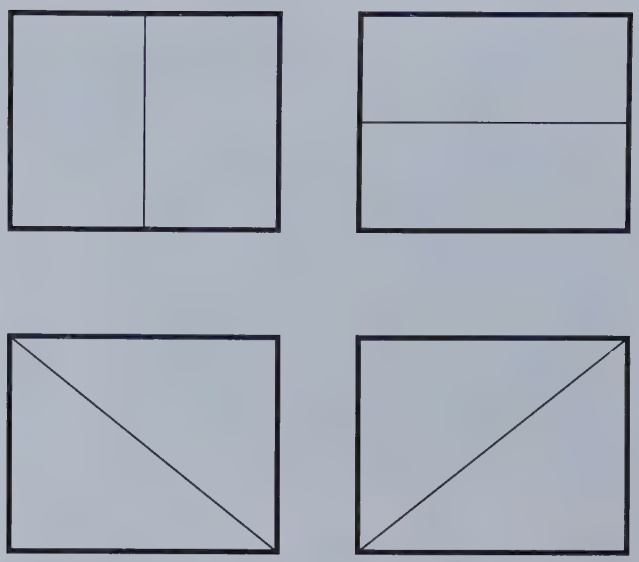


Figure 8–15 The picture plane can be divided vertically, horizontally, or on either diagonal to assess balance. The central line is called an axis.

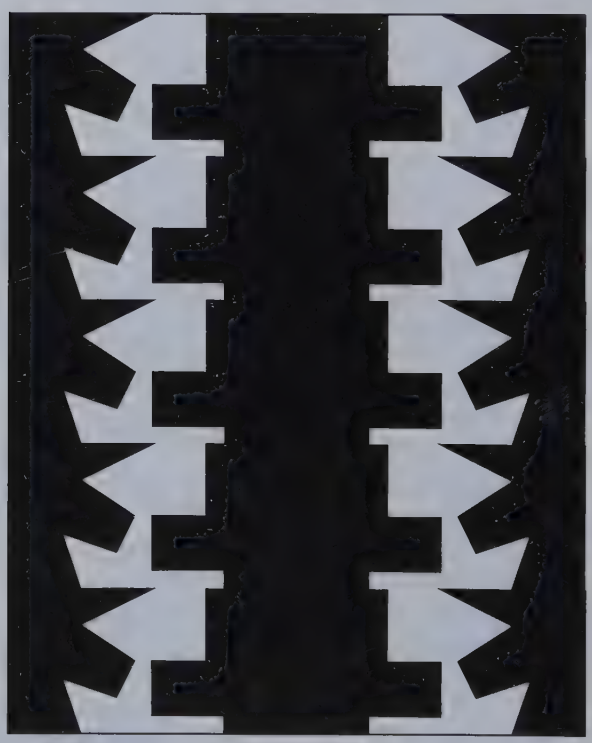


Figure 8–16 Symmetry is formal or perfect balance.

Asymmetrical Balance

Asymmetrical balance, also known as *informal balance,* is the balance of elements that have unequal visual weight. Using asymmetrical balance (also known as *asymmetry*) sensitizes us to comparative visual weights. We must carefully consider positioning unequal elements in the picture plane. Asymmetrical visual compositions can be equalized by the thoughtful placement of visually heavy elements. In this manner, the visually "light" half of a composition can be weighted to compete with the "heavy" half of a composition. Awareness of the innate visual weight of design elements and types of contrast supports our mastery of compositional asymmetry. In this example, a large-scale simple element is balanced by a complex element. [8.17] Here, a dark-value complex line element is balanced by a focal point established by direction and isolation. [8.18]

An element's visual weight is often dependent on its placement in the picture plane. Elements positioned closer to the bottom of a picture plane seem heavy. The same

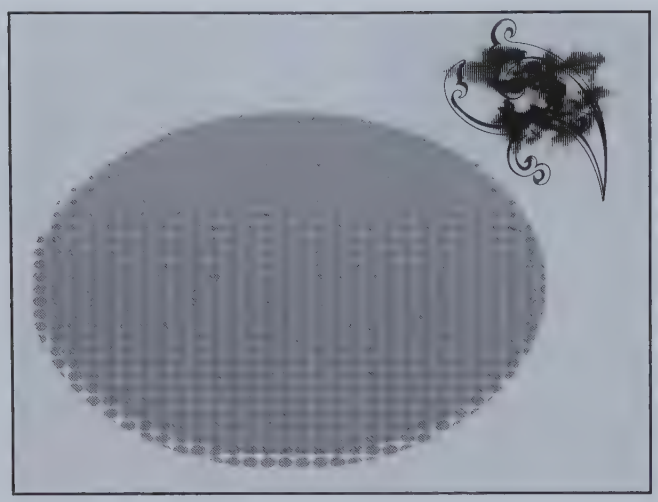


Figure 8–17 Asymmetry is also called informal balance. Here, a high-contrast, small-scale, complex shape balances a large-scale, simpler shape. Courtesy of Becky Koenig.

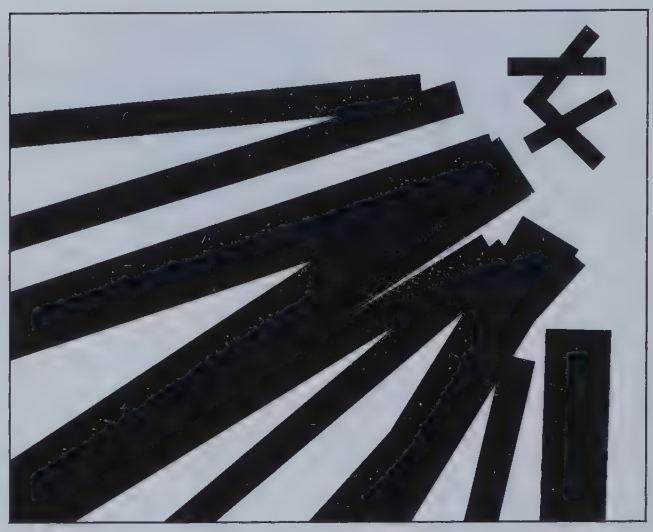


Figure 8–18 Balance by Direction. The heaviness of the left side is balanced by the directional force to the right.

elements become lighter when placed nearer the top of the picture plane. [8.19] This visual sensation is a direct result of our intuition about the gravity of objects.

Crystallographic and Radial Balance

Other forms of compositional balance include *crystallographic balance,* which is a pattern or subdivision of the picture plane, such as a grid, to achieve balance. *Crystallographic* refers to an interlocking crystal-like formation that integrates the positive with the negative spaces of the composition, often forming positive/negative ambiguity. [8.20]

Another simple form of balance is *radial balance,* which is characterized by radiating or emanating forms that originate from a specific point or area. The "vortex" of radial balance can be located virtually anywhere within the picture plane and still sustain compositional balance. [8.21]

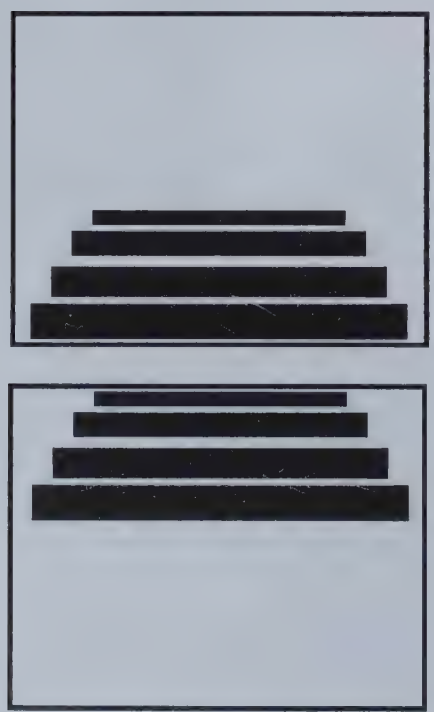


Figure 8–19 Objects at the bottom of the picture plane innately have more weight due to our sense of gravity. Notice that the elements can be made lighter in visual weight by moving them upward in the picture plane.

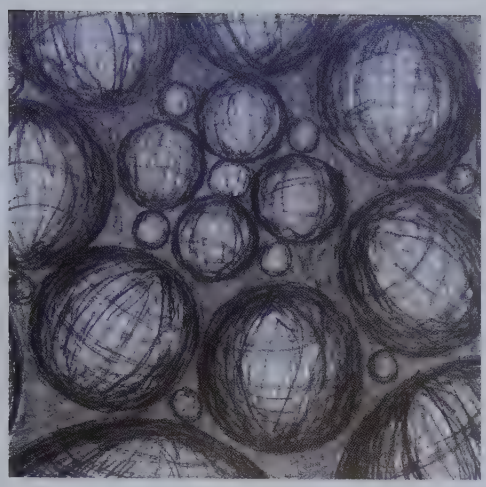


Figure 8–20 Crystallographic balance is based on some type of interlocking structure. Student work by Charlene Smerdon.

Figure 8–21 Radial Balance. All the compositional forces radiate from one point for balance. Student work by Chu Chan. Courtesy of Becky Koenig.

Instinct plays an important part in all of art, particularly in the design principle of balance. We sometimes innately "feel" that objects are misplaced, too heavy, complex, dark, and so on. The guidelines outlined here are meant to supplement our visual instincts, not replace them.

DESIGN PRINCIPLES—PROPORTION AND SCALE

SCALE Scale is alternately referred to as either an art element or a design principle. *Scale,* also known as proportion, is the relative size of objects in an artwork. Scale variation can be used either to signify depth or serve to organize dissimilar objects. Objects with similar scale will appear to visually unify. Scale also indicates the size of our human body in relationship to objects around us everyday or the human scale in relationship to the size of a work of art.

The concept of proportion and scale is also a way of structuring compositional space. Proportion of objects and space in design can have great impact on the visual weights and layout of a composition. Contrast of scale/proportional size can draw attention to key areas of a composition. The relative proportion or scale of spacing within a composition is also of critical importance. For instance, by manipulating the scale of negative space, we can create isolation in design. Alternately, if proportions of realistic objects seem to be out of scale with each other, this creates a feeling of disquiet in the viewer.

DESIGN PRINCIPLES—MOVEMENT AND RHYTHM

Movement

The design principles of movement and rhythm are distinct yet interconnected concepts. *Movement* refers to actual motion or the inference of motion in a work of art. There are forms of art that have actual movement, such as kinetic art and video. In installation art, for example, the viewer's actual movement through the art piece or interaction with it may be a factor in the impact of the piece. Artists also exploit various methods to depict motion in a static piece of art.

Frozen motion is an expression of movement through a static image; for example, an animated object, such as a human body that is caught in motion, leads our mind's eye to fill in the "before" and "after" of the narrative. Motion can also be communicated by blurring, which suggests action or speed, as in a photograph of a moving object. Superimposed sequential views of an object moving through space also generate an illusion of movement.

Figure 8–22 A shape gradation suggests movement. Student work by Julie Marks.

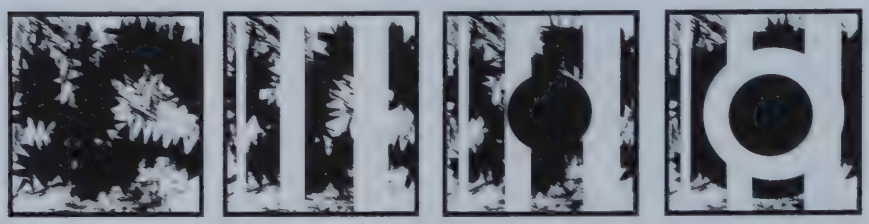


Figure 8–23 Movement can be expressed through a serial progression in a sequential composition. This gradation study moves from complex to simple and from textural areas to a single shape. Student work by Darlene Mastrangelo.

GRADATION A gradation or gradient also indicates movement. A *gradation* is any type of gradual visual change, which may also suggest motion. The steps of a sequential gradation are a primitive form of visual animation. [8.22] Scale, shape, color, position, texture, value, and color can all be gradated, or changed by degrees. A gradation implies movement because it simulates time: before, during, and after—are all contained in one composition. Our eye follows a gradation to its logical ending, as it presents us with a coherent progression. A gradation also functions to lead the eye to a focal point. [8.23]

DIAGONALS *Diagonals* suggest directional force in a composition, as they convey an innate sense of movement. [8.24] Diagonals that radiate from a given point, for example, cause our eye to move both into and out from that center point. In contrast, compositions based on horizontals and verticals, like a grid, have a high degree of visual stability.

Rhythm

Rhythm is a concept directly corresponding to movement but has some distinct differences. Rhythm is a visual quality of movement, a pulsation in our eye's perception of a work of art. Visual *rhythm* describes the manner in which our eye moves through a composition.

Rhythm is a term that describes the essential beat and time structure of music. When an artwork possesses visual rhythm, it has a visual beat or repeating element that generates movement. Repetition of a similar direction, such as a repeated group of diagonals, for example, will cause our eye to move systematically and kinetically through a composition.

Two main types of visual rhythm are staccato and legato, terms that are borrowed from music. Legato rhythm in music is a sustained or unbroken sound, smooth and connected. Visual *legato rhythm* is a smooth unbroken path through a composition. [8.25]

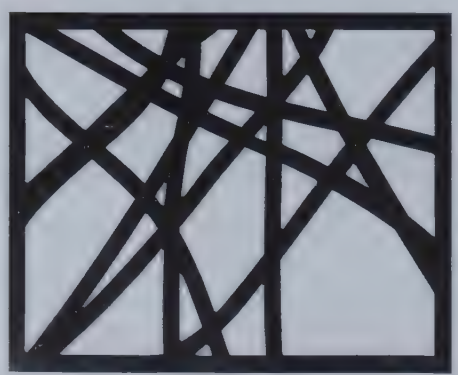


Figure 8–24 Repetition as well as diagonals suggest movement.

Figure 8–25 Legato rhythm is a smooth fluid rhythm. Student work by Charlene Smerdon.

Figure 8–26 Staccato rhythm is an on and off broken rhythm.

Figure 8–27 Progressive rhythm emanates or gradates from a given point. Student work by Cathy Van Galio. Courtesy of Becky Koenig.

Staccato rhythm in music is a percussive sound or beat. Visual *staccato rhythm* is a broken "on and off" configuration of disconnected repetitious parts, a visual beat. [8.26] *Alternating rhythm* can be realized by alternating two or more different types of rhythmic structures to interact together in a composition. The alternating structures may be either interlocking parts of staccato and legato rhythms or layers of different types of rhythmic strategies.

Progressive rhythm utilizes a radiating or gradating progression to express rhythm. [8.27] Progressive rhythm correlates with radial balance, because forms emanate from one or more points. A visual analogy to progressive rhythm is a rock thrown into a pond, with ripples emanating in circles from the place where the rock splashes into the water. A *gradation* can also depict progressive rhythm because it describes a visual chain of events. A gradation sequence sets up a visual rhythm because gradual changes seem to encapsulate time.

Compositional excellence is achieved by the simultaneous engagement of manual, intellectual, and visual processes. Design principles provide us with guideposts for visual structures, each principle emphasizing a unique compositional strategy.

Activities

1. Line Position Proximity Study

Objective: For the student to understand the relationship of line position to the picture plane. Unity through the repetition of direction, line width, and continuity should be considered. Proximity of line groups can also be put into use.

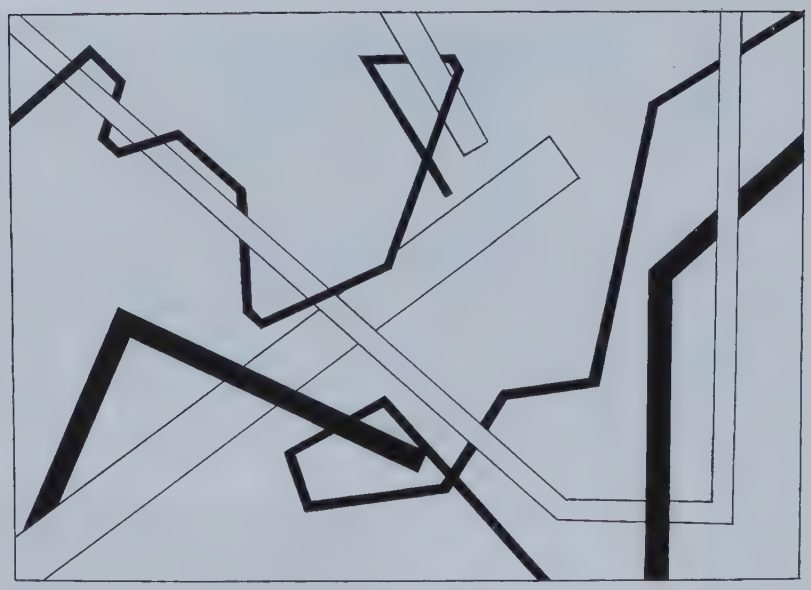


Figure 8–28 *Line Position Proximity Study*. Student work by Amy Claroni. Courtesy of Becky Koenig.

Media: Marker on hot press illustration board.

- Using only straight ruler lines of different widths, make a composition of vertical, horizontal, and/or diagonal lines. The lines should divide the picture plane.
- The concepts of unity to be used are repetition (of the line element), proximity, and variety. Lines can be grouped in several areas, adding areas of interest. All positions—vertical, horizontal, and diagonal lines—can be used, but you may want to select only two or three choices. Diagonals can vary within 360 degrees, but be careful to use some position repetition to organize the composition.
- There may be heavy black lines showing little white space, or the lines can be white against black. The main concept is to create a unified composition with as much variety as possible.
- Do several thumbnail sketches first, then draw one choice up to size on tracing paper and transfer it onto a board.
- The final piece should be accurately inked with marker. [8.28][8.4]

2. Shape Emphasis Study

Objective: The student will use invented shapes to create a visual point of emphasis in a composition. A structural manipulation of positive and negative areas will produce a strong composition.

Media: Cut black shapes on white illustration board.

- Create a shape with an interesting contour that is invented, or pick one from the group of shapes that you invented for the Chapter 7 Activities. The shape may be curvilinear, rectilinear, or a combination of both.
- The shape should be varied in scale either by drawing it in different sizes or by changing the scale on a photocopier.
- Cut shapes of different sizes out of good-quality black paper. Use the shapes to make a collage, creating a point of emphasis at the same time. Carefully design the positive and negative compositional space.
- A point of emphasis can be established by the use of isolation, direction, scale contrast, position contrast, and so forth.
- The composition can be varied by the reversal of shape, overlapping, and cropping. Try to use only asymmetrical balance for this study. [8.29][8.11][8.7]

Figure 8–29 *Emphasis Study*. Note that the emphasis is on the isolated shape on the right.

3. Economy Study

Objective: To use and understand the concept of economy in a figure/ground relationship.

Media: Cut out white shapes on a black ground made with black paper, all presented on illustration board.

- Use the same shape as in Number 2 to create a study that explores the concept of economy.
- The shapes of different sizes should be white shapes on a black ground for this study.
- Create a study using extreme economy of means. In this piece you should use five or fewer repetitions of the shape. The shape may be of any scale.
- The composition should be well designed, with thought put into the placement of the few shapes and the figure/ground relationship.
- This study should be substantially different from the shape emphasis study. [8.8]

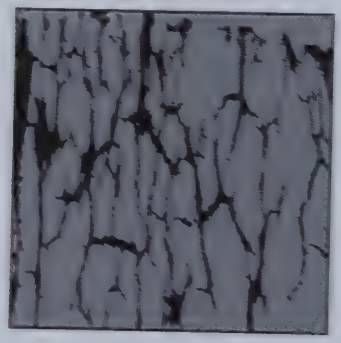
4. Texture Rhythm Study

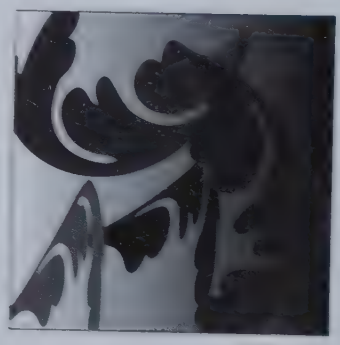
Objective: The student will use experimentation with texture, to create a rhythmic visual structure in order to understand the design principle of rhythm.

Media: Mixed media in black and white and gray. Paint, drawing media, and textured surface, on illustration board.

- Use the concept of rhythm to create a composition. Keep in mind the use of repetitive elements to keep the eye moving throughout the composition. You may use legato, staccato, alternating, or progressive rhythm.
- Parts of this composition are to be made with various textures in black, white, and gray media. You can use the invented textures that you made for Activity 4 (above). Or you can use actual textured surfaces, transferred textures, and patterns.
- The textures should be inset into your rhythmic structure. Some textures can be repeated to emphasize visual movement within the piece.
- The final study will be a collage that has a rhythmic design and uses some combinations of textures in all areas of the composition.
- The piece may be made in a traditional picture plane or have an alternative shape. [8.30]
- *Digital Texture Studies:* A computer version of this activity is to explore the preset textures in the graphic styles palettes and to vary them by using filters and or effects. Computer drawings can also be texturized by filters or effects, such as SVG filters or "crystallize." [8.31]

Figure 8–30 *Texture/Rhythm Study.* Student work by Mimi Fherle.





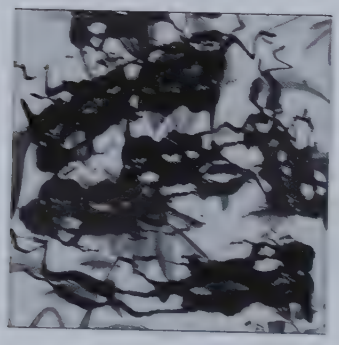


Figure 8–31 Digital Textures. An exploration of textures made digitally, some of which are modified by filters and other effects tools.

Figure 8–32 *Movement Montage Study.* Student work by Satoshi Tsuchiyama.

5. Movement Montage

Objective: To design and create the illusion of movement.

Media: Cut photocopies on board.

- Find several images from magazine photos that strongly suggest motion, frozen motion, or blurring. Or the nature of the form should suggest innate movement.
- Make ten black and white photocopies of one of the images.
- Make a montage using all ten photocopies in whole or in part to express the design principle of movement. You may overlap or cut apart the image, or use the whole image.
- The final piece should be an abstract version of the original image using the repetition of the image to convey an overall sense of motion.
- The motion study can break free of the traditional picture plane format and be a defined or irregular shape. [8.32] [8.27]

Glossary

Asymmetrical balance The balance of unequal art elements in an artwork; also called informal balance.

Balance A design principle that addresses the equal distribution of visual weight in any given piece of art.

Continuation or continuity A visual pathway through a composition.

Crystallographic balance A pattern or subdivision of the picture plane, such as a grid, used to achieve balance.

Design principles Theoretical guidelines for the compositional placement of art/design elements.

Economy The use of a minimal amount of visual information in art or design.

Emphasis A design principle that establishes a particular place of interest in an artwork. Emphasis is synonymous with a point of focus or focal point in art.

Gestalt The perception of a configuration, pattern, structure, or wholeness.

The term Gestalt can be roughly translated from the German as *configuration.*

Gradation Anything that changes gradually in a visual sense. Scale, shape, color, position, texture, value, and color all can be gradated.

Movement Both the literal and the suggested motion in a work of art.

Proximity Referring to the Gestalt concept of the physical grouping of objects.

Radial balance This form of balance employs radiating or emanating forms from a given area or object.

Repetition Repeating any art element or concept in order to unify a design.

Rhythm A design principle that encompasses the visual quality of movement, describing the manner in which our eye moves through an artwork.

Scale The relative size of objects in an artwork.

Similarity According to Gestalt theory, when we perceive similarity in a design, our eye picks up the pattern or configuration of the similar elements.

Symmetry Formal balance, which is perfect balance vertically, horizontally, or diagonally along an axis. In a symmetrical composition, the elements of the composition are perfectly equal.

Unity A design principle that addresses the way the parts of a composition visually hold together. *Unity* is also referred to as *harmony.*

Variety The variation of any art element or art concept in a repetitious visual structure.

Chapter 9

Color Schemes and Harmonies

LEARNING OBJECTIVES

- To understand and use the concept of color harmony.
- For the student to explore the types of standard circle-based color schemes: simple, opposing, and balanced color chords.
- To grasp the idea of informal color harmonies, setting up criteria for individualized color schemes.
- Introducing the idea of color discord and its role in art and design.

INTRODUCTION

A color scheme provides *color harmony,* a combination of color "notes" that are visually pleasing when grouped together. Color schemes are strategies that assist an artist in the selection of harmonious colors. When forming a set of harmonious colors, color schemes provide a framework of source hues, which then can be varied by value, saturation, or proportion. Each color scheme is adaptable to the personal preferences of the artist or designer. Color schemes provide a starting point for traditional color harmony and a foundation for using colors together in groups.

Standard or formal color schemes are made from methodical, controlled hue selections from the color circle. Each scheme exploits the physical location of hues on the color circle to create a guideline for each form of color harmony. Every style of color harmony has its own innate characteristics and visual personality. Color schemes can also be customized to fit the personal preferences of the artist or designer through the variation of hues and the proportion of each color in a composition. Formal color schemes are standardized by circle-based location of hues, but an artist may also formulate color schemes with custom-made guidelines.

Color schemes or harmonies have three principal categories: simple color harmonies, opposing/contrasting harmonies, and balanced harmonies. *Simple harmonies* are color schemes based on a small number of neutrals or hues. *Opposing/contrasting harmonies* are founded on the idea of hue contrast, either opposing hues or hue temperature contrast. A *balanced color harmony* is a color chord in which hue selections are based not only upon their placement, but specifically upon their spacing on the color circle.

The color schemes discussed in this chapter are formal/standard harmonies frequently used in art and design. Color schemes based on a small number of source hues possess a kind of built-in color repetition, causing them to be harmonious and visually unified. Larger numbers of hues in a color scheme can make color harmony more challenging to achieve.

SIMPLE COLOR HARMONIES

Simple color harmonies are economical in nature because they are built upon neutrals, a single hue, or a narrow group of neighboring hues. The advantage of a simple color harmony is robust color unity; its disadvantage is diminished color variation.

Achromatic Harmony

An *achromatic color* is technically a neutral, that is, a color that contains no hue. A *chromatic color* is a color that is based on a discernible source hue from the color circle. An achromatic color scheme includes only achromatic colors: black, white, and a full value tonal range of grays. A looser definition of achromatic colors can include chromatic neu-

Figure 9–1 A monochromatic harmony has variations on a single hue, such as blue. The hue variations on blue, for example, could include slightly more BG or BV versions of blue, along with tints, shades, and tones of blue.

trals created from complementary mixtures or muted earth colors mixed with black and white. Achromatic schemes are very harmonious and rely on light/dark value contrast or warmth and coolness (as in warm and cool grays) for variety. An achromatic harmony is characteristically subtle and quiet in nature. Cubist and some Futurist paintings utilize achromatic harmony to portray planar forms. [12.9]

Monochromatic Harmony

A *monochromatic color scheme* is built upon a single hue from the color circle. The concept of hue variation (see Chapter 3) demonstrates the wide assortment of color alternatives available within a monochromatic color scheme. A blue monochromatic scheme, for instance, may include pure blue; slightly warmer or cooler blues; tints, shades, and tones of blue; and blue intermixtures with other hues. Because we are creating variations on a single hue, the resulting group of colors is very harmonious. [9.1] One disadvantage of a monochromatic scheme is the deficiency of hue contrast; value and saturation are the main contrast variables. Monochromatic color schemes are extremely unified, set a strong color mood, and convey the personality and character of an individual hue. This work by the American artist Childe Hassam, (1859–1935) is painted in an almost monochromatic palette with varieties of yellow-greens along with tints and slight variations on the dominant hue, to portray a landscape with an intense sensation of light. This work illustrates the variation that can be achieved through the limited means of a monochromatic color scheme, particularly in the depiction of light, high- and low-saturation keys. [9.2]

Analogous Harmony

An *analogous color scheme* is based on the concept of a *color family.* Analogous hues are two or three adjacent or neighboring hues on the color circle; an example of an analogous harmony is blue, blue-violet, and violet. [9.3] Analogous harmony can be seen as an expanded and more varied version of a monochromatic harmony because of its greater number of source hues in comparison with other simple color schemes. Most analogous harmonies are low in hue contrast, with the exception of hue groups that cross over between warm and cool sides of the color circle, for example, the YO, yellow, and YG analogous group. To vary the hues of an analogous color scheme, hues may be intermixed, tinted, shaded, toned, and/or slightly modified with other hues. [9.4]

Simple color schemes can be thought of as "layman's" color harmonies because they are reliable, harmonious, and agreeable. Each simple color harmony has its own distinctive traits. An achromatic scheme is neutral, and it often emphasizes high value contrast. Monochromatic or analogous schemes are very harmonious with strong visual unity. However, any one of these color schemes may be used in an atypical manner to produce unexpected effects.

Figure 9–2 A monochromatic color scheme, although simple, can be widely varied. This painting by Claude Hassam represents form and light with variations on yellow-green. *Spring, Navesink Highlands* [New Jersey] (1908), Hassam Childe. Oil on canvas, 25-1/8" × 30-1/4" (63.6. × 76.6 cm). Smithsonian American Art Museum, Washington, DC, U.S.A./Art Resource, NY.

Figure 9–3 Analogous harmony is formed from an adjacent group of two to three hues from the color circle.

Figure 9–4 A group of analogous harmonious colors based on R, RO, and RV, along with tints, shades, and tones of these hues.

CONTRASTING OR OPPOSING HARMONIES

Opposing or contrasting color harmonies maximize hue contrast. These color harmonies tend to generate a lot of visual excitement. Kandinsky considered contrasting harmonies to be indicative of modernity in his 1912 book, *On the Spiritual in Art*: "We can easily conclude that harmonization on the basis of simple colors is precisely the least suitable for our own time.... Clashing discords, loss of equilibrium, principles overthrown, unexpected drumbeats, great questionings, apparently purposeless strivings, stress and longing ... chains and fetters broken ... opposites and contradictions—this is our harmony."

Complementary or Dyad Harmony

A complementary color scheme begins with a perfectly balanced opposing pair of hues (a *dyad*) from the color circle. Complementary colors, as previously discussed, consist of two hues positioned directly across the color circle from each other. [9.5] The most common dyad pairings are made up of one primary and one secondary hue as follows: blue and orange, red and green, and yellow and violet. There are also three tertiary dyads: red-orange opposing blue-green, red-violet opposing yellow-green, and blue-violet opposing yellow-orange. When we place full-saturation complementary hues directly adjacent to each other, a visual effect called complementary vibration occurs (see Chapter 4).

A color scheme produced from a complementary pair generates a great deal of visual interest and scintillation or contrast. The two hues of a dyad can also be mixed together such as (red and green) to generate a soothing group of neutral or partially neutralized colors called *chromatic neutrals*. A complementary harmony consists of pure hues, such as yellow opposing violet, and then tints, shades, or tones of the pure hues and/or their complementary intermixtures (chromatic neutrals). [3.22] The color proportion of complementary hues may be equalized for balance, or one hue of the dyad may be allowed to dominate a composition. In this painting by the American artist James Rosenquist (1933–), loosely based on a color scheme of blue and orange, the

Figure 9–5 Complementary harmonies are based on opposing hues on the color circle. Red–green, orange–blue, and yellow–violet are complementary pairs.

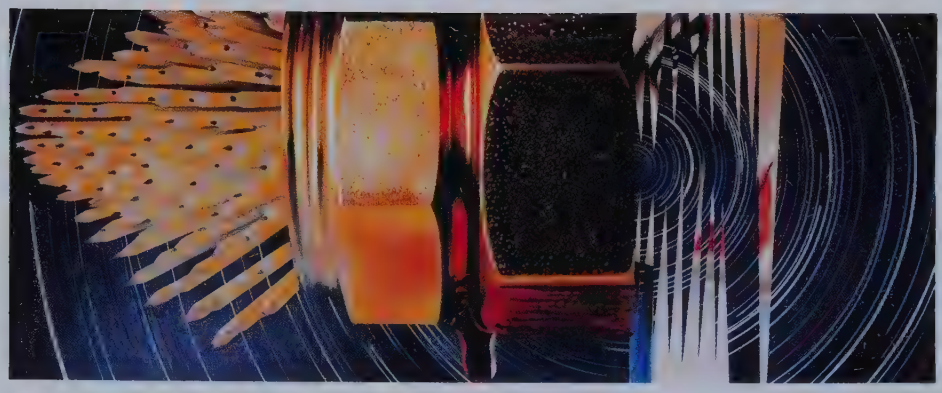


Figure 9–6 The complementary color scheme in this painting, with a primarily blue–orange complementary combination, creates a luminous color juxtaposition. *Leaky Ride for Dr. Leakey* (1983), James Rosenquist. Oil on canvas, 78 in. × 198 in. San Francisco Museum of Modern Art, Gift of Harry W. and Mary Margaret Anderson. 92.279.A-C. © James Rosenquist/Licensed by VAGA, New York.

complementary contrast creates a scintillation between the hues creating a sensation of light that emanates from the work. [9.6]

The complementary color scheme is the magical yin/yang of color harmony, expressing polar opposites through color, yet balanced by the hue foundation of the three subtractive primaries. A complementary harmony, although it is based on a visual contrast, ranges from subtle to vibrant, expressing color harmony or movement by complementary vibration. Pure complementary hue pairs are characteristically vibrant and visually "loud," but they also can be muted and enriched by the quiet trait of chromatic neutrals. Our visual reaction to complementary pairs is intermingled with the concepts of afterimage, color balance, and physical complementary vibration.

Cool/Warm Color Harmony

Cool/warm color harmony, based on the concept of contrasting color temperature, is a four-hue color scheme that is more loosely structured than most formal color schemes. Cool/warm contrast emphasizes divergence in color temperature, a metaphorical approach to color that stems from human color associations: We *feel* that colors are warm (like red for blood) or cool (like blue for water), based on our personal and cultural experience. The cool side of the color circle ranges from violet to green. The warm side of the circle spans from red to yellow. [2.15] Borderline hues that are not definitively cool or warm are red-violet and yellow-green. RV and YG are the chameleons of color temperature, as they may be deemed to be either warm or cool colors. A cool/warm color scheme is composed of one pair of neighboring warm colors and one pair of neighboring cool colors. Since RV and YG are mutable temperature hues, they can be either cool or warm depending on how they are paired with other hues. RV is cool when paired with violet and warm when paired with red. YG is cool when paired with green and warm when paired with yellow. An example of a cool/warm color scheme is red–orange and orange as a warm pair opposed to green and blue–green as a cool pair. [9.7]

The advantage of cool-warm harmony is its extreme flexibility because any two cool/warm pairs create a scheme, regardless of their placement on the circle. A cool/warm grouping could be comprised of red, red-violet, violet, and blue-violet, which is also considered to be an extended analogous grouping, but technically correct for a cool/warm harmony. This flexibility gives each cool/warm scheme a contrasting yet diverse personality. A cool/warm color scheme retains its contrast when the cool and warm hues are not physically mixed together. The problem with intermixtures of cool/warm hues is that they may produce low-saturation colors, or too many colors to be visually coherent in a composition. However, cool or warm hues may be tinted, shaded, or toned without

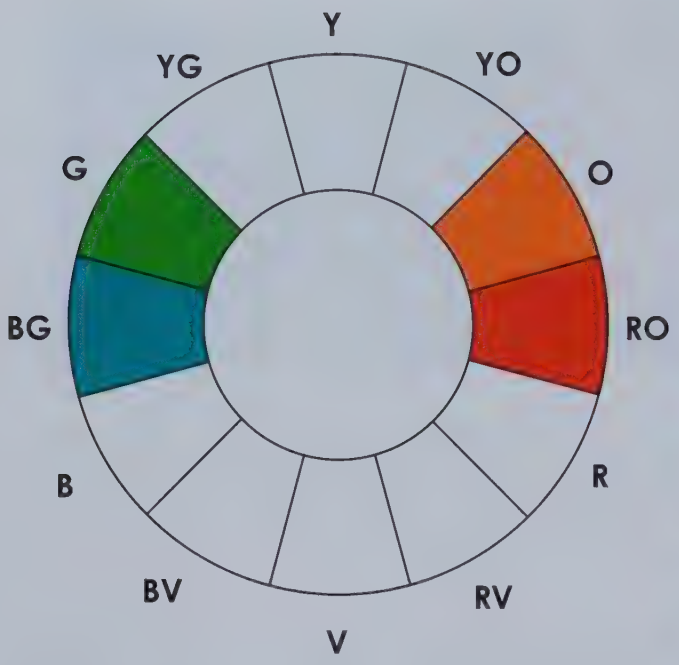


Figure 9–7 A cool/warm harmony uses a pair of any two adjacent cool hues with a pair of any two warm hues.

Figure 9–8 A montage study using a cool/warm color harmony of orange and RO versus green and BG. *Warm/Cool Montage Study*, student work, by Andrew Sheffer.

canceling out their temperature contrast. [9.8] Cool or warm pairs can also be intermixed (cools with cools or warms with warms) to form intermediate colors between the hues. For example, a color between yellow and yellow-orange may be mixed to widen color alternatives. A painting by Paul Cezanne, entitled *Apples and Biscuits,* utilizes mainly a casual cool/warm harmony of orange-RO and blue-BG. [9.9] The cool/warm contrast that Cezanne often employed creates a type of flickering rhythm throughout the painting, caused by small marks of adjacent colors with subtle temperature contrasts.

Double Complement Harmony

A *double complementary scheme* is a contrasting color scheme with four hues, which employs two adjacent complementary pairs. [9.10] The purpose of a double complementary harmony is to soften and expand a complementary dyad, for example: green and yellow-green opposed to red-violet and red. A double complementary harmony can function by: utilizing pure hues and intermixtures between complements, and tints, shades, and tones of any of these. This harmony is a more structured approach to a cool/warm color scheme that stresses the contrast of opposing hues. [9.11]

Split Complementary Harmony

A split complementary harmony can be regarded as either a contrasting harmony or a balanced harmony. A *split complementary scheme* is a three-hue color harmony based on an opposing dyad. A split complementary harmony begins with a dyad but rather than having a direct hue complement, the two hues on either side of the actual complement are chosen, for example, violet in opposition to yellow-orange and yellow-green. This harmony is based on a narrow V configuration inscribed in the color wheel as shown. [9.12] Beginning on the opposite side of the color circle, the split complement of yellow is red-violet and blue-violet. This color scheme is traditionally viewed as a softened complementary scheme or a modified triadic harmony.

Hue intermixtures, tints, shades, or tones generate many colors in a split complementary harmony. Intermixtures between all three split complementary hues lead to numerous colors that can be difficult to unify. If a very harmonious and unified effect

Figure 9–9 This painting uses a cool/warm harmony; in this case, the warm colors are more highly saturated than the more subtly nuanced cool colors. *Apples and Buscuits* (1880), Paul Cezanne. Oil on canvas, 46 cm. × 55 cm. RF1960-11. Photo credit: Franck Raux. Musee de l'Orangerie, Paris, France. Reunion des Musee Nationaux/ Art Resource, NY.

Figure 9–10 A double complement has two adjacent complementary pairs.

Figure 9–11 A double complementary harmony based on RV–YG and R–G. Hues can be mixed in almost any way within this scheme.

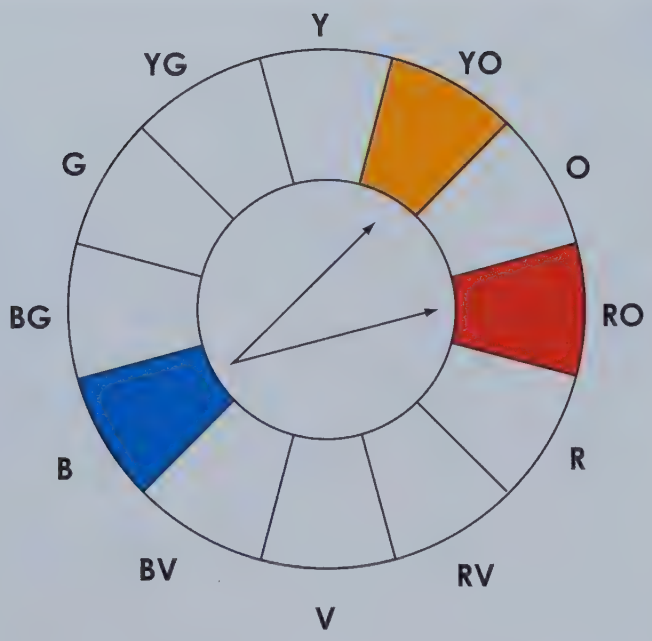


Figure 9–12 Split complementary harmony is an expansion on a dyad, although it uses the two adjacent hues rather than an actual complement.

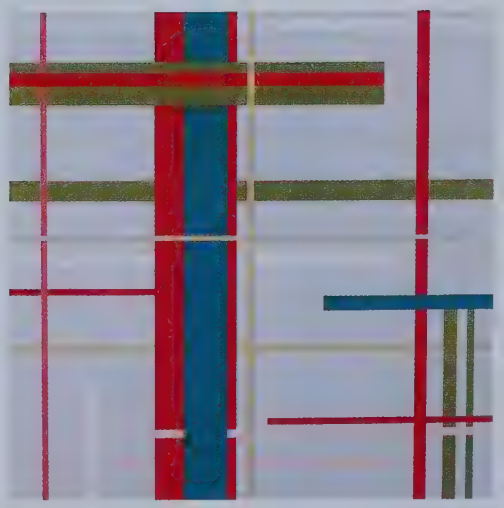


Figure 9–13 A split complementary harmony starts with three hues, along with their tints, shades, and tones. Shown here, a digital line study based on red, BG, and YG. Student work by Bonnie Sue Bacon. Courtesy of Beck Koenig.

is desired, only pure hues and their tints, shades, and tones should be chosen. [9.13] Split complementary harmonies are characterized by color balance and visually arresting combinations of contrasting hues.

BALANCED COLOR HARMONIES

Balanced color harmonies are based on separate, balanced hue selections from the color circle, often referred to as color chords. The concept of a *color chord* correlates with music; "color notes" (hues) are thought to have a pleasant "color sound," like the spaced apart notes of a musical chord. Two categories of balanced color harmonies are triads and tetrads. Both of the following color schemes are based on a geometric figure that is inscribed inside the color circle as a guideline for hue selection. A triangle defines a triad harmony, and a square or rectangle delineates a tetrad harmony.

Triadic Harmony

An equilateral triangle inscribed in the color wheel points to three equidistant hues, which form a *triadic color scheme.* The triad is a classically balanced color harmony familiar to artists and designers. [9.14] There are two well-known triadic choices: a primary triad of red, yellow, and blue and a secondary triad of violet, orange, and green. [9.15] There are also two tertiary triad harmonies: RO, YG, and BV; and RV, YO, and BG. All of the triadic color chords are extremely harmonious and have the advantage of being simultaneously balanced and diverse. [9.16]

The triadic scheme best retains its harmony when applied in an uncomplicated fashion, by utilizing only pure hues of the triad and their tints, shades, and tones, omitting intermixtures between hues. Artists have employed triads extensively, particularly the primary triad, for its purity. The modernist painter Piet Mondrian preferred the primary triad, using it almost exclusively for its clarity and distinct hue contrast. The primary triad also formed a type of color balance that was an oft-used color language

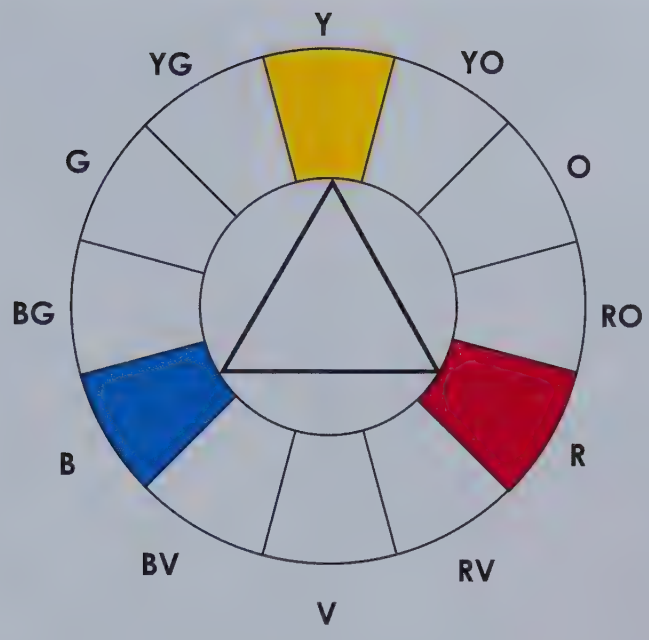


Figure 9–14 A triadic color harmony is based on a triangle inscribed in the color circle for hue selection. The primary triad is shown here.

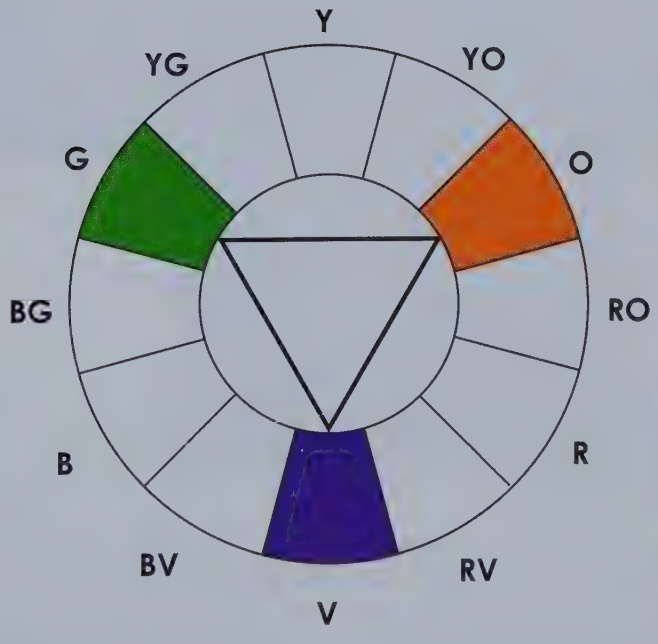


Figure 9–15 The secondary triad.

Figure 9–16 A color harmony based on the secondary triad. The hues are tinted, shaded, and/or toned but not intermixed.

throughout the history of European painting. This painting, an altarpiece of the *Deposition*, by Rogier Van der Weyden, has a rhythmic placement of brilliant reds, blues, and yellows in the gold leaf and opulent garments. [9.17]

Tetrad Harmony

A tetrad is a balanced four-hue color scheme, which gives it more complexity and depth than other color harmonies. Tetrads are defined by either a square or rectangle inscribed

Figure 9–17 *Deposition*, by the Northern Renaissance painter Rogier Van der Weyden (1399–1464), is an altarpiece that uses the primary triad of red, yellow, and blue in a balanced and rhythmic manner. *Deposition* (1436), Rogier (Roger) Weyden. Wood, 220 cm × 262 cm. Museo del Prado, Madrid, Spain. Erich Lessing/Art Resource, NY.

inside the color circle. The three tetrads created by squares are: Y, V, RO, BG; YO, BV, R, G; or O, B, RV, YG. [9.18] Square tetrad harmonies employ two complementary pairs, which are more widely spaced on the circle than the hues of a double complementary scheme creating a divergent yet stable group of colors.

A traditional tetrad is based on a rectangle inscribed in the color circle to obtain the following four-hue combinations: YG, RV, YO, BV; Y, V, B, O; or G, R, Y, V. [9.19] Since tetrads are based on a larger (four-hue) selection of hues, they are somewhat less harmonious than the schemes with a more limited number of hues. To enhance the harmony of a tetrad, it may be paired with other methods of formulating color harmony, such as keying color value or saturation to a similar level. The advantage of a four-hue color system is both its flexibility and complexity, which leads to a broad-based color harmony.

KEYED COLOR HARMONIES

Value and saturation keys are instrumental in creating visual coherence, harmonizing a large range of colors. Color keys can visually connect a group of hues through common, similar color characteristics, such as the use of predominantly dark or light values. [9.20] A consistent saturation level is also effective in harmonizing a large group of colors, resulting in a collection of colors with an equal degree of high or low saturation. Color

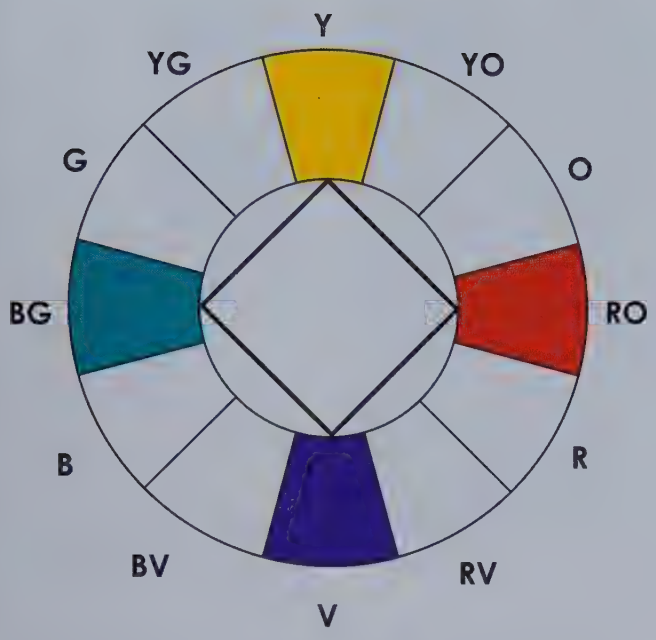


Figure 9–18 A tetrad harmony is based on a square inscribed in the color circle.

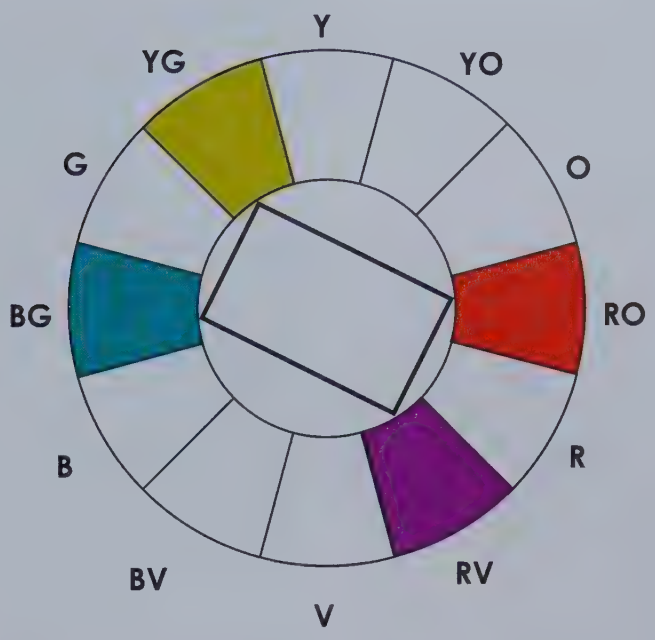


Figure 9–19 A tetrad harmony can also be based on a rectangle inscribed in the color circle.

Figure 9–20 A light-, medium-, or dark-value key (as shown here) allows a large number of colors to harmonize.

keys harmonize because colors that share common traits visually level out color diversity and create a visual tapestry.

COLOR HARMONY AND DISCORD

Color harmony is a formal goal of much art and design, but there is also a role for color groupings that are stridently different, perhaps harsh in contrast. Color discord is formed by a purposefully dissonant combination of colors in order to attract attention and is expressive in nature rather than harmonious. Examples of discordant color combinations might include: many strong hues together, a pure hue in combination with muddy, low-saturation colors, tones of numerous colors with a few pure bright harsh colors, or colors such as dark pinks, yellow greens, and olive greens that are traditionally less preferred than other colors. There are, however, no set "rules" for discordant colors due to the fact that color discord is highly subjective in nature. [9.21] The expressive quality of color discord is discussed in Chapter 11.

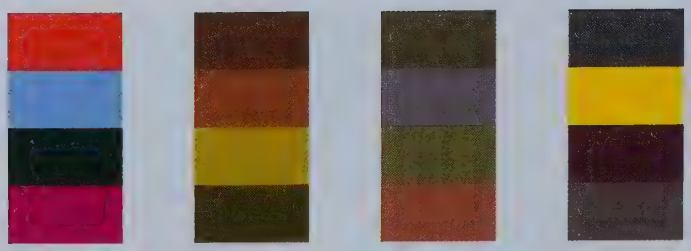


Figure 9–21 Some examples of discordant color combinations: from left, several high-saturation colors with a low intensity, "muddy" color, shades of yellow and green, all low-saturation colors, and all low-saturation, neutralized colors with a single pure hue.

INFORMAL COLOR HARMONIES

Informal color harmonies are more flexible, less fixed color strategies than standard color schemes. The artist can customize these harmonies to meet the color requirements of a subject, theme, or function of an artwork. Informal color schemes are often established by *color characteristics* rather than circle-based hue selections. The following is a list of informal color harmonies that have flexible rules and are able to form many possible color combinations.

SIMPLE COLOR SCHEME: A color scheme based on variations from any two to four hues. Hues may be tinted, shaded, or toned to create a group of colors.

HIGH-SATURATION COLOR SCHEME: All high-saturation key hues and colors form this color scheme. Any number of hues or colors can be used as long as they are pure and intense. This scheme is often called a high-key color scheme. [9.22]

LOW-SATURATION COLOR SCHEME: A color scheme of all low-saturation key hues and colors, formed by the addition of black or varying amounts of gray to make tones. One or two purer colors can be added for contrast.

NEUTRAL WITH ACCENTS: Achromatic black, white, grays; nearly achromatic earth colors, chromatic neutrals, and very low-saturation tones are selections for this color harmony. One or two stronger color accents can give the harmony some interest and variety.

LIGHT-VALUE KEY COLOR SCHEME: Any number of hues keyed to medium-light or very light values are in this color harmony, also called a pastel color scheme. A few darker or stronger colors can be used for contrast.

Figure 9–22 A high-saturation key harmony is all high-intensity, pure, or almost pure colors.

Figure 9–23 A limited hue saturation contrast scheme can be based on several hues that vary in tonal saturation. This can be made with mixtures of hues in different proportions with various grays. Student work by Molly J. Hughes. Courtesy of Beck Koenig.

DARK-VALUE KEY COLOR SCHEME: The same as above but with very dark values and formed with shades, complementary mixtures, or dark tones. [9.20]

LIMITED HUE SATURATION CONTRAST: Any one to three hues can be used to create a wide variety of saturations by using sequential tones, as in the Munsell system. Adding different amounts of varied values of gray into a pure hue can do this. There should be high-saturation versions of each hue as well. [9.23]

CHROMATIC GRADATION: A color scheme from hues with some distance between them on the color circle; pure hues, as well as subtle gradations between hues are used, for example: yellow, green, and blue, which would consist of Y, YYG, YG, G, GGB, BG, B, and variations. Chromatic gradation is most effective when presented in a sequence compositionally since it is a logical progression. [9.24]

VALUE GRADATION: Any two to four hues and their light-to-dark value gradations make another orderly color scheme. Approximately five value variations on each hue make the scheme more effective, especially when value gradations are in order as an integral part of the harmony.

Figure 9–24 A chromatic gradation is a progression of colors that connect adjacent hues from the color circle by using in-between colors. Shown here, a gradient from yellow to YG to green to BG to blue.

Figure 9–25 Becky Koenig, *Clock*, Oil on panel, 24″ × 48″, collection of the artist. © Becky Koenig, 2003. The selection of two colors from a triad, such as blue and yellow from a primary triad, creates an informal color harmony. Courtesy of Beck Koenig.

TRIAD VARIATION: Two of the three hues chosen from a triad construct a strong harmony, for example, orange and green or green and violet from the secondary triad. [9.25]

Formal and informal color schemes or harmonies are the first step in exploring color combinations. Color schemes have rules that may seem rigid but, in fact, are flexible and amenable to change and manipulation by the artist. Color schemes furnish a stable foundation for inventing a broad range of color harmonies.

ACTIVITIES

All of these compositions combine color harmony with design principles and elements for developing mastery of color design.

1. MONOCHROMATIC LINE STUDY

Objective: The objective of this study is for the student to work with line as a division of the picture plane. The student will use the line in varied directions (horizontal, vertical, and diagonal) and vary the line width. Unity by color, continuation, and line proximity should be explored. The student will also gain an understanding of the use of a monochromatic color system.

Media: Collaged paper or computer illustration on board.

- First, make some plan drawings, 10″ × 10″ or 10″ × 12″, using a ruler. The drawings should use straight ruled lines in any combination of three directions (horizontal, vertical, or diagonal) to divide the picture plane. Lines may end or crop out of picture area. Try to create unity by using the idea of continuation of the lines, either literally or implied.
- Pick out a monochromatic color scheme using Color Aid® paper or found colored paper. Try to get as much variation on the hue as possible; for example, for blue, use its tints, shades, and tones.
- Using colored pencils or markers, color the areas of your sketch with your chosen colors or photocopy your sketch and try the color scheme in multiple layouts.
- Inset colors into your design, by cutting out the lines or letting lines of color show between adjacent shapes.
- You can also execute this study on computer. Pick out colors and save them to your swatch palette first. Try various color arrangements in the design. [9.26]

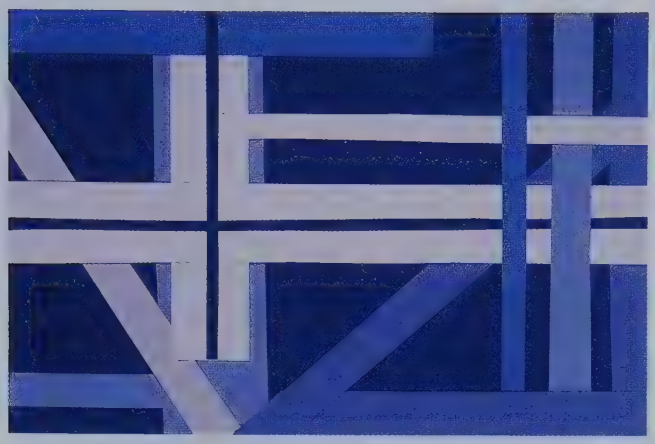


Figure 9–26 *Monochromatic Line Study,* student work by Noelle Hubert.

2. Invented Shape Complementary Study Or Split Complementary Study

Objective: The goal of this study is for the student to use a unique invented shape as a basis for a composition using figure/ground ambiguity, scale contrast, and overlapping shapes. A complementary or split complementary color scheme will be utilized and explored.

Media: Acrylic paint on board.

- Create at least ten invented shapes. Make sure they are not overly complex. The shapes can be curvilinear, rectilinear, or organic.
- Photocopy or draw your shape in multiple sizes. Design your composition to the desired size by tracing. Overlapping is encouraged.
- Try to make all areas of the composition equally interesting. Color will be used in all positive and negative areas.
- The composition can be completely filled with positive shapes if this doesn't become too complex. Then erase any unnecessary lines to simplify composition.
- Pick either a complementary color scheme or a split complementary scheme.
- If you pick a complementary color scheme, for example, RO and BG, you may use intermixes between the complementary colors. The color harmony choices are: pure complementary hues, intermixtures between the complementary hues, and tints of any of these hues or mixtures. Make a swatch sheet of possible colors.
- If you choose to use a split complementary system (for example, yellow, blue-violet, and red violet), you can use the pure hues, tints, shades, and tones.
- Work out a color placement plan with markers or colored pencils on a trace or a photocopy of the composition.
- Transfer drawing to illustration board and paint in all areas with flat color according to your chosen scheme or plan. Leave no white areas. [9.27]

3. Cool/Warm Grid Study

Objective: The student will use the design principle of unity by use of repetition and continuity, also emphasizing variety. The student should explore the idea of a theme and variations on several geometric shapes. The color scheme is a cool/warm color harmony.

Media: Acrylic paint on board.

- Start this study by making a 10″× 10″ grid using 2″ increments. This can be drawn on sketch, trace, or grid paper. This grid has five 2″ squares, both horizontally and vertically.

Figure 9–27 Invented shape split complementary study. Student work by Laura Shoemaker. Courtesy of Becky Koenig.

- Pick two or three geometric shapes to start with from the following: circles, triangles, squares, rectangles, and diamonds.
- Use these shapes as starting points for designing each square increment in your grid. Divide each grid unit into variations on chosen shapes.
- Make the sides of each grid unit integral parts of the design, with positive and negative spaces equally interesting.
- The composition should use the principle of unity by repetition and continuity, yet it should have variety and not be a consistent pattern.
- The design of a grid unit may be repeated, if position or color is changed, for variety.
- When designing the grid, use continuity. Connect one part of the composition to another. Some grid lines can be eliminated in the process, but the study should be visibly based on a grid.
- After drawing several plans for this design by hand or on computer, the colors should be chosen.
- A cool/warm color scheme will be used, emphasizing warm/cool contrast. Pick a neighboring pair of warm colors, for example, yellow and yellow-orange. Pick a pair of cool colors, for example, blue and blue-green.
- Remember that if RV or YG are chosen, you must decide whether these colors are warm or cool. RV is cool if paired with violet and warm if paired with red. YG is cool if paired with green, but warm if paired with yellow.
- Use the pure hues such as Y + YO, mixtures between Y + YO and tints of any color. Warm and cool colors should not be mixed together because this will diminish the contrast.
- A color swatch sheet can also be used to make color decisions.
- Transfer the design onto illustration board and paint, leaving no white areas. [9.28]

Additional Cool/Warm Study: Cool/Warm Montage Study

- Make a study from found images in a cool/warm color scheme. The images can be from magazines, from digital photos made by the student, or found online. The two unifying factors should be color and continuity between images. Images should be chosen by their common visual characteristics and will be assembled according to the visual principle of unity. [9.8]

Figure 9–28 Cool/warm grid study. Student work by Simone Theriault.

4. Triadic Masterwork Study

Objective: The objective of this study is to familiarize the student with the compositional structure of a particular museum-quality artwork. The student will learn to analyze composition forces within the work. The textures, paint application, and surface of the work will be studied and reproduced. A triadic color scheme will be used to change the color message or theme of the work.

Media: Acrylic paint on illustration board.

- The student will look through art history books or survey some art history sites on the Internet to pick a color work that he or she wishes to study.
- The artwork should be a museum-quality work by a well-known artist.
- First, the student should make a drawing from a good reproduction of the original work. The reproduction should be in color and a good size.
- A triad harmony should be chosen that is quite different from the original color scheme of the painting. Before painting, plan where the colors should go.
- Remember, the point is to change the color system of the original as much as possible, while exactly emulating all the textures and the shapes as precisely as possible.
- The triadic system should be used. For example, red, yellow, and blue, along with tints, shades, and tones. Use no intermixes of the hues.
- The final piece should resemble the original in composition, but send a different color message. [9.29]

Informal Color Harmony and Discord

Objective: To set criteria and create a color harmony or discord based on the student's own "rules."

Media: These studies can be made on computer, or with colored paper or paint.

- Form your own criteria for an informal color harmony, using the examples in the end of this chapter.
- The harmony can be used for one of the assignments above, or to make several examples of swatch groups to "test" the rules of the personal harmony. The rules for the harmony should be clear enough for other students to use for their own work; the harmony rules can thus be exchanged between students for use in experimental studies by students that did not make up the harmonies.

Figure 9–29 Triad masterwork study based on a painting by Gustav Klimt. Student work by Lisa Webb.

- Similarly, the student can create either criteria for color discord or simply make a study with discordant colors. Color discord is highly personal. What types of color combinations are considered to different people to be discordant, harsh or clashing? Do other students agree that your color groups are discordant?

Glossary

Color chord A group of hues chosen from the color circle that are spaced apart, such as red, yellow, and blue. The music chord–color chord analogy refers to the spacing of three or four color "notes" to produce harmony.

Color contrast The manner in which colors may contrast are by value (light/dark), hue, temperature (cool/ warm), complementarity, and saturation (muted/ brilliant).

Color schemes or harmonies Color circle–based formal hue selections used to achieve color harmony.

Color temperature Refers to our sense of warm or cool colors. For example, red is warm in temperature because it refers to blood, fire, and the sun; blue is cold in temperature because of its reference to water, ice, and the sky. Each primary and secondary hue also has a cool or warm aspect; for example, red is cooled when blue is added, creating red-violet.

Cool/warm color harmony A four-hue color scheme that is less structured than most. Cool/warm contrast emphasizes differences in color temperature. Example: RO and red opposite BG and blue.

Double complementary A four-hue contrasting color scheme. This scheme uses two adjacent complementary pairs, for example, yellow, YO, violet, and BV.

Informal color harmonies Harmonies with flexible rules, created by an artist.

Split complementary harmony A contrasting or a balanced harmony. A split complementary scheme has three hues and is based on an opposing dyad. Instead of using a direct complement, however, the two adjacent hues to the actual complement are chosen. Example: The split complement of violet is YO and YG.

Tetrad A four-hue color system that is balanced based on either a square or rectangle inscribed in the color wheel.

Triad An equilateral triangle inscribed in the color circle describes three equidistant hues that compose a triadic color system. The triadic system is a classically balanced color scheme and is used by many artists and designers. Example: orange, green, and violet.

Chapter 10

Designing with Color

LEARNING OBJECTIVES

- For the students to learn and work with design principles in connection to color theory concepts.
- To learn to design with color in conjunction with color unity, emphasis, balance, space, and rhythm.
- To design through utilizing types of color contrasts for emphasis, color modulation for space, and relative color weights for balance.

INTRODUCTION

This chapter is an exploration of color as an essential visual force to build unity, emphasis, balance, rhythm, and illusionist devices in composition. Design principles and color concepts have been discussed thus far as separate entities for clarity of understanding. In a real-life design or art-making process, however, an artist composes with many formal design elements, principles, and color concepts simultaneously. This chapter focuses on the interrelationship between color study concepts and design principles in order to achieve design mastery through color. Color dynamics, the interplay of color, is the key to effective manipulation of color that guides the process of design.

COLOR UNITY

When designing chromatically, the attributes, characteristics, and harmonies of color can be used to reinforce concepts of repetition, proximity, and continuity and produce visual unity. Both the selection and compositional placement of color also strongly support unity in design.

Color Repetition

Color harmonies are a straightforward method to establish color unity in design. Color schemes are fundamentally hue selection guides; each scheme possesses a distinct color character or personality. Hue repetition effectively allows color harmonies to visually unify a composition. [10.1] Most color schemes are based on one (monochromatic) to four hues (tetrad) and their variants. The hues of a color harmony may produce a large group of colors, but those colors remain visually cohesive because they are based on a small number of source hues (an analogous scheme, for example, has two to three hues).

The concept of color repetition can operate outside of the realm of standard color schemes. A single pigment, included in the many color mixtures of a painting, can fashion an understated color repetition to harmonize diverse images and elements. The color mixtures of a painting can also be devised from a restricted number of pigments, or *controlled palette*, which supplies a subtle harmony between compositional areas. Conversely, colors selected in an arbitrary, random manner lack a color strategy and may cause a composition to be disjointed.

Consistent Color Key or Temperature

Color keys support the concept of color consistency. Use of a single color attribute or characteristic (such as saturation or value) can effectively form a visual connection that ties together even diverse compositional elements. By matching colors to the same value (all light, medium, or dark value levels) or saturation (dull or bright keys), we have the

Figure 10–1 Color Similarity. Top: Repetition by an analogous scheme (based on blue and BG) and continuity by a color gradation unify this composition. Bottom: The same composition with arbitrary color appears to be less unified than the previous illustration.

capability to organize a large number of colors into unified groups. [10.2] A consistent saturation level, for example, imparts a uniform color *personality* to a composition; low-saturation colors seem quiet; high-saturation colors seem loud. The phenomenon of optical mixture of keyed color illustrates color unity because optical mixes merge a large group of colors into one low-contrast unit. This blending occurs because colors of a similar value or saturation have an ambiguous relationship, seeming to be interwoven together into the same spatial plane.

A consistent approach to color temperature also produces compositional unity; an all-warm or all-cool composition is easily perceived as a whole. [10.3]

Figure 10–2 Color keys can also effectively implement unity. In this Indian illumination, all the warm and cool colors are at a similar high-saturation key. India Rajasthan, *Mewar Kama Shoots a Love Arrow at Shiva*, page from a copy of the Gita-Gauri (*Song of Gauri*), c. 1675/80. Opaque watercolor and gold on paper. 23.2 cm. × 19.7 cm (9 1/8 × 7 3/4 in.); Outermost Border: 27.4 × 21.2 cm (10 3/4 × 8 5/16 in.); Paper: 28.9 × 22.6 cm (28.9 × 8 7/8 in.). Louise A. Lutz Endowment, 2004.454, The Art Institute of Chicago. Photography: © The Art Institute of Chicago.

Figure 10–3 Color unity can be established by a narrow selection of color characteristics, such as a dominant, warm, overall coloration, like the light-orange and dark-red color in this painting that unify the overall composition of this triptych. *Rouen Cathedral Set V* (1969), Roy Lichtenstein. Oil and magna on canvas. 63-5/8" × 14-7/8" × 1-3/4 (161.61 cm × 360.36 cm × 4.45 cm). San Francisco Museum of Modern Art, Gift of Harry W. and Mary Margaret Anderson. © Estate of Roy Lichtenstein.

Color Continuity

Color continuity can be produced by the progressive sequencing of colors. Our eye follows the steps of a logical color sequence in the same way that we follow a continuity path through a composition. A color progression can be built from a continuous color gradation such as a value gradation, chromatic gradient, some type of pattern/color alternation, or a saturation gradation. [10.4] In 1960s posters, very saturated color patterns

Figure 10–4 A Color Gradient. Top: Colors can be chromatically gradated from one hue to another to lead the eye. Bottom: Colors can become progressively lighter or more saturated to lead us to the focal point of pure red.

and gradations were part of elaborate psychedelic compositions in color lithographed prints to publicize rock concerts. In the figure below, by Victor Moscoso, the text forms a pattern in color that emanates outward from the figures, to frame and draw attention to them. The poster design from this period is both topical and sophisticated, capturing the spirit of the time in its graphic use of fluorescent, neon-colored pigments. [10.5]

Color Similarity, Proportion, and Distribution

The Gestalt concept of proximity group formed by similar visual characteristics is readily reinforced through color. Simply put, objects of the same color will bond together visually, regardless of their location. The notion of color similarity also causes *color distribution or dispersal* to be an effective formal device for unity. We visually read similar elements as unified building blocks of an artwork, so when similar colors are dispersed throughout a composition, they produce an inner cohesion. [10.6]

Color proportion or dominance is directly related to the relative physical area that each color occupies in a composition. By using larger areas of one particular color (from a group of colors) in a composition, we can construct color dominance, causing visual unity. For example, a large proportion of yellow-orange in this yellow-orange and

Figure 10–5 *Family Dog #59* (1967), Victor Moscoso. Rhino Entertainment, 2008. www.victormoscoso.com. Color lithograph. A psychedelic-era poster by Victor Moscoso (1936–) has a gradation in spacing between the split complementary colors of red, yellow–green, and blue–green. The gradation in this spacing intensifies the cool/warm contrast to draw the eye to the figure.

Figure 10–6 *Feathered Tabard or Tunic.* Andes, 7th–15th century. Polychrome feathers sewn to cotton tabby ground, 98.0 cm. × 53.0 cm. © The Cleveland Museum of Art. Seventy-fifth anniversary gift of Mr. and Mrs. Cedric Marks, 1992.105. Color unity is achieved by the colors distributed throughout a loosely patterned feathered textile because our eye groups repeated colors.

Figure 10–7 *Objects in Space*/Selby Gallery Poster (1999), April Greiman. Offset lithograph. Design/videography: April Greiman. The yellow and yellow-orange are dominant in this poster, which uses a cool–warm color scheme. The dominant warm color unifies this complex, dynamic design.

violet harmony creates a more compelling color unity than equal areas of yellow-orange and violet. [10.7]

COLOR EMPHASIS

Color Contrast

A focal point or point of emphasis can be regarded as a form of visual dominance in which a portion of a composition strongly attracts visual attention. *Color emphasis* is a color strategy that is diametrically opposed to the stratagem of color unity. Instead of causing colors to unify or merge together, the strategy of color emphasis is to establish a color area that is visually powerful in the context of a composition. Generating a point of emphasis with color is relatively simple because of color's ability to visually *contrast.* Johannes Itten identified the methods in which colors contrast in his book, *The Elements of Color* (1970). Itten described principal types of color contrasts as light/dark contrast (value), hue contrast, cool/warm contrast (temperature), saturation contrast (purity), simultaneous contrast, complementary contrast, and contrast of quantity (proportion). Color contrasts are always relative to and dependent upon the color of their compositional environments. Some specific examples of color contrast include: a dark-value green in light yellow environment (value contrast); a highly saturated orange in low-saturation, gray-green surroundings (saturation contrast); or a cool blue-green in a warm, dark-red context (temperature contrast). Color contrast is formed by an abrupt color departure from the majority of colors that surround it, constructing area(s) of visual emphasis in a composition.

Complementary and Temperature Contrast The strength of complementary pairings cannot be overstated as a potent form of color contrast—for example, a composition with a dyad contrast of pure yellow with muted violet will direct attention to the yellow areas. [10.8] The additive color circle also serves as an alternate guide to choose sets of complementary hues, such as magenta contrasting with green, blue (violet) opposite yellow, and cyan opposed to red. Cool/warm colors effectively establish a focal point by contrast of temperature: a warm color placed in a dominantly cool composition or a cool color used in a dominantly warm environment.

Figure 10–8 In this study, the complementary contrast draws our eye to the yellow area. Student work by Bonnie Sue Bacon. Courtesy of Becky Koenig.

HUE CONTRAST Hue contrasts have the capability of constructing a focal point, particularly when using the potent hue contrasts between the medial primary hues: red, green, yellow, and blue. For instance, a red focal point can be placed in a blue environment or a blue focal point in a yellow environment. Secondary hues can also be paired for divergence, such as an orange focal point in a green environment. The most powerful hue contrasts are between full-saturation colors.

COMBINATION OF COLOR CONTRASTS Several types of color contrast can be combined for even stronger emphasis. For example, a light-value warm color (such as a pale orange) in a composition of low-saturation, dark-value, cool colors (such as a dark muted violet) draws interest. Any type of chromatic contrast (contrasting hues) paired with value or saturation contrast is an effective way to allow a color to visually dominate.

COLOR CONTRAST GROUPINGS A color contrast grouping such as cool/warm colors or light/dark colors can also produce an effective visual hierarchy to generate a focal point. [10.9] Visual competition can weaken a focal point; thus, a contrasting color combination

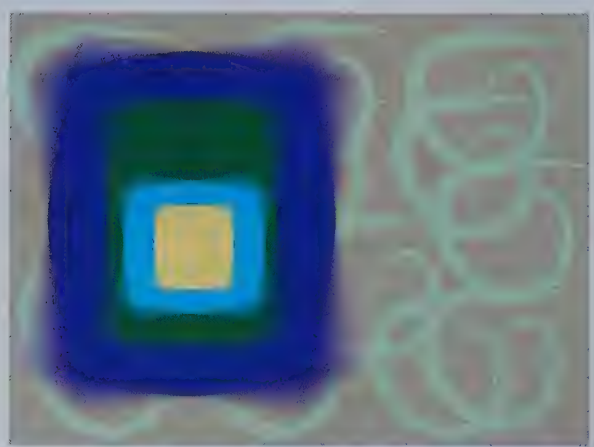


Figure 10–9 An area of value and hue contrast stands out in an environment of low-contrast colors. Courtesy of Becky Koenig.

Figure 10–10 Focal point study. Student work by Bonnie Sue Bacon. Courtesy of Becky Koenig.

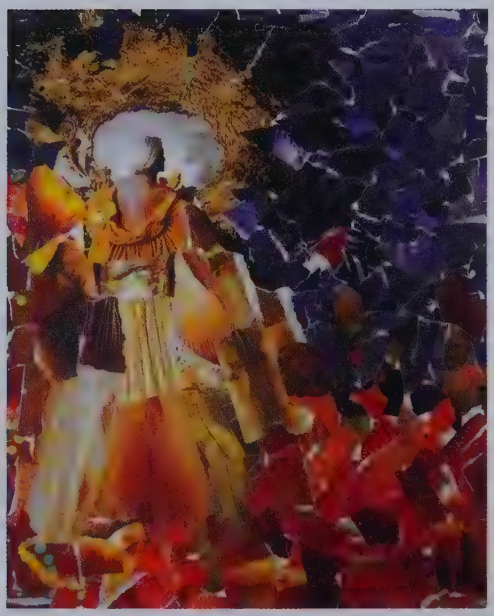


Figure 10–11 A unique color or color anomaly establishes a point of emphasis. Student work by Charlene Smerdon.

must oppose the overall color environment. For example, a strong light/dark contrast focal point should not compete with other value contrasts, or the intended focal point will lose its visual impact. When a single color dominates a composition, an area that opposes it in hue, value, color temperature, complement, or saturation will contrast and be emphatic. [10.10]

Unique Color

A *unique color* is a departure from the colors that dominate a composition, made more striking by being used in only one location compositionally. A color that is unique or an anomaly in an artwork attracts attention because its color identity stands alone. [10.11] A color can also be compositionally unique because of its complementary, hue, temperature, or value contrast with surrounding colors.

Color Gradation

A color gradation is a gradual change in color that functions to direct our eye compositionally. Color may be gradated by changes in saturation (getting purer or duller), by changes in value (lighter or darker), or by chromatically blending from one hue to another around the circle like Y, YG, G, and so on. A color gradient shapes a logical sequence that we can visually follow. [10.5] The end of a sequential gradation can be made emphatic through a unique or contrasting color.

COLOR BALANCE

Relative Weight of Colors

It may seem strange that the phenomenon of color is something that has weight. Colors have relative visual weights, which are a major consideration in *color balance.* The visual weight of any individual color is, of course, relative to and interactive with its overall color environment or context. Some colors are, however, inherently visually heavy,

Figure 10–12 Colors can be considered light or heavy because of factors such as value, saturation, and temperature.

while others seem to be intrinsically lighter in weight. [10.12] Heavy colors include dark colors (dark values), high-saturation colors (pure colors), or powerful hues. Warm hues: red, red-orange, orange, yellow-orange, and yellow are considered to be powerful hues and, at full strength, tend to visually dominate other colors. Traditionally, colors that are pale in value or low in saturation (muted) are thought to be light in weight. Cool colors are customarily believed to be less dominant than warms, but this is certainly not an ironclad rule. Achromatic colors such as pale or medium grays are also visually lighter in weight than, for instance, a saturated color like RO. A dark achromatic color like black or dark gray is almost always visually heavy. The relative weight of colors becomes more apparent in the context of interactive color groups.

High-contrast colors presented in adjacent combinations also have visual weight. [10.13] There are four main types of contrasting color groups, which have already been discussed: primary or secondary hue contrasts such as red opposite yellow-green, complementary contrasts such as orange opposite blue, cool/warm contrasts such as yellow opposite blue-violet, and value contrasts such as dark and light violet.

Asymmetrical Color Balance

Colors are a decisive factor in the compositional equation that forms asymmetrical balance. A designer can fine-tune color positioning to balance even an unbalanced

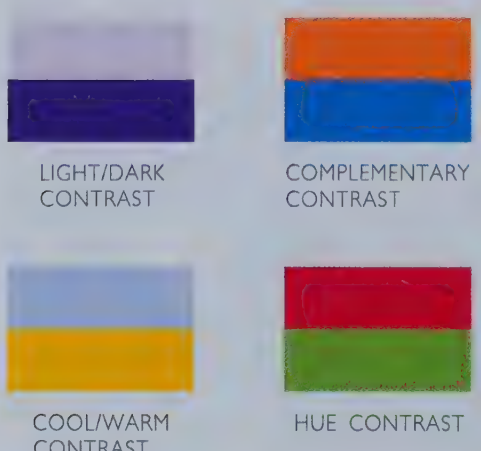


Figure 10–13 Some types of color contrasts have visual weight.

Figure 10–14 Color placement equalizes an asymmetrical design: A small, dark-blue shape on the top right of the composition is balanced by concentric circles of light-value hues on the left. *Asymmetrical Balance Study* by Nicole Land. Courtesy of Becky Koenig.

asymmetrical design. Color is such a forceful design element that both the selection and location of colors can bear the weight of a balanced design.

The relative proportions of color areas in a composition can also determine visual balance. The concept of color dominance is helpful when manipulating color areas in design. Color weight is relative and interactive, dependent both on the color placement and mass, the amount of physical area covered by each color. To achieve equal balance, the color dynamic of a composition can be finely manipulated. Color balance is established like any type of visual balance, by counteracting visual weight from side to side, top to bottom, or diagonally. The bottom of a two-dimensional composition always has more inherent visual weight than the top because of our sense of gravity. Using heavy colors in the bottom half of a composition may cause a bottom-heavy imbalance that can be countered by a weighted color in the top half of the composition. [10.14] Color balance may also be attained by the distribution of weighted colors throughout a composition. [10.6]

The placement of color groupings is a key to the overall dynamic of a design. An exercise that varies the locations of the same group of colors assists our understanding of color balance. [4.27] Color balance exercises are fairly simple when executed digitally, as colors can be moved and changed instantly.

Color and Symmetry

An effective way to understand the visual forces in color balance is to manipulate colors within a symmetrical structure. A design that is mirrored on either side of a line of symmetry or axis has symmetrical-formal balance. Perfect symmetry in color design similarly has equal placement of colors on either side of the axis. A simple exercise can help us better understand the relative weight of colors; by positioning colors unequally on either side of the axis of a symmetrical composition, we can attempt to "unbalance" it. By upsetting the symmetry of a composition, we can better appreciate the visual force or weight of colors and color groupings. Through this process, compositional balance may be radically transformed by the color differences on either side of a symmetrical structure. [10.15]

Radial Color Balance

Radial balance can be defined by elements that emanate from one or more points in a composition. The "vortex" of a radial color composition can also function as a starting

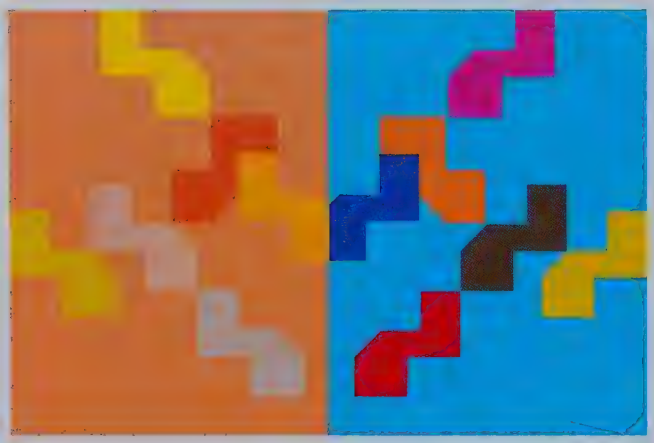


Figure 10–15 A symmetrical structure can be shifted in balance by an asymmetrical color placement.

Figure 10–16 Radial balance is enhanced by a radial color gradation. Student work by Kristen Walkowniak.

point for a color gradation. Colors can gradate darker from a light point, lighter from a dark point, or change in hue or saturation. In a radial composition, a gradient produces an area of emphasis and compositional balance and can emanate color luminosity. [10.16]

COLOR TO DEPICT FORM, LIGHT, AND SPACE

Artists use colors to depict reality by reproducing close observations of the play of light upon objects. A primary focus of illusionistic art is the creation of form, light, and space by color selection, nuance, mark, and position.

Color Value and Spatial Illusion

Malleability of color value is critical to both the illusionistic depiction of space and the volumetric form of objects. Color can be easily scaled into value steps and offer the artist a sequence that emulates light and form by gradations of light, medium, and dark colors. Colors can be shaded by addition of color modifiers such as black, complements, grays, earth neutrals, and by careful manipulation of cool and warm mixtures. All of these strategies will produce value gradations to build volume and a sense of light.

Form and Color

Local color is a concept that in reality is tenuous, based on our assumption of the generalized color of an object. The reality of color is based on the subtraction and reflection of light wavelengths as described in Chapter 1. A novice painter looks at an object, such as an apple, and sees its local color. Upon closer observation, he or she notices that the apple has assorted colors due to both the color and textural variations on the apple's skin and the quality of light upon it. The amount and type of light that illuminates an object drastically affects our perception of its color. Concentrated observation is necessary to perceive and emulate the play of light on objects. Forms or volumes are of two main types—either rounded or flat-sided, which affect the way that light describes them. When lit, a round or irregularly shaped object has a color/value gradation. Flat-sided objects or planar forms have distinct shapes of light and dark colors defined by the edges of each plane. Upon close observation, numerous distinct colors are evident in even a solid-colored object. Perceptible light/color variations are described as highlight, light, shadow, core of shadow, and reflected light. The rendering of an object is dependent on form and color considerations, which can become a complex process for a painter. A painter must perceive chromatic distinctions, identify the colors seen, and be able to

re-create the colors by paint mixtures. Areas of color must be sensitively handled and accurately situated to render an illusion of form. Accurate color in appropriate places furnishes a rendered object with volume and light through nuances of hue, value, and color temperature. [12.2][12.3]

Color and Light

The manner in which objects are described by color and light is an important aspect of Western art. In an illusionary painting, the quality of light affects all of the objects in the painting. A cloudy, diffuse light, the light of a candle in a dark room, or warm sunny light at noon all present the artist with diverse color problems. The light striking reflective objects or a lighted atmosphere (sky) presents particularly difficult challenges. Time of day is interconnected with the quality of light and shadow depicted. Strong midday sunlight casts small crisp shadows and is cooler than light in the morning or evening, making colors appear highly saturated. Cool light on an overcast day will mute warmer colors and illuminate cool colors. Dim twilight illuminates blues and violets and subdues reds and greens. Nighttime is about the harsh contrasts of dark and light. The darks of night are depicted as blues, black, or violets. A light illuminating a dark setting is translated in painting into white, yellow, or orange. Artificial light, like fluorescent light, is cool, in contrast to the warm quality of incandescent light or firelight. Identical objects painted or photographed in varied settings alter substantially in color. Paintings that are depictions of light itself, such as sunsets and lit skies, are particularly difficult to achieve. The artist is, in essence, trying to recreate an additive effect of light with subtractive pigments. The results for many inexperienced artists are heavy and unattractive. A highly refined sense of color and paint application is necessary for the rendering of light in artwork. It is akin to painting "air." [10.17]

Figure 10–17 *Twilight in the Wilderness* (1860), Frederic Edwin Church. Oil on canvas, 101.6 cm × 162.6 cm. © The Cleveland Museum of Art. Mr. and Mrs. William H. Marlatt Fund, 1965.233. In this painting, a spatial illusion is formed by atmospheric perspective with colors that are backlit by the sunset; colors of the mountains are darker and more muted as they recede into the distance silhouetted against the golden twilight of the colors in the foreground, although muted are more defined and detailed to visually push them forward in the illusionary distance.

Figure 10–18 Luminescence is produced by a subtle gradation of one hue into another, using saturation or value steps. An illuminated area should be lighter or brighter than its surrounding colors.

A small area of light that seems to glow or emanate can portray the illusion of *luminescence*. Luminescence is depicted by a sequence of gradated values or hues into a darker or more muted saturation, a chromatic gradation, or a complementary gradient. These effects form an illusion of light emanating from within an artwork. [10.18] The illusion depicted in this painting by Georges de la Tour is produced through a strategy called chiaroscuro (high value contrast). Candlelight illumination was a favorite device used by de la Tour, who casts warm, glowing reds, oranges, and yellows upon the flesh and clothing of the figures in this dramatic tableau. [10.19]

Figure 10–19 *Nativity,* Georges de La Tour. Musee des Beaux-Arts, Rennes, France. Scala/Art Resource, NY. Georges de la Tour was known for his paintings of extreme lighting contrasts that effectively conveyed the sensation of candlelight.

Iridescence is a color effect that can depict the type of rainbow that we see in an oil/water mixture, on the inside of a shell, or in some satin fabrics. Iridescence is also referred to as *scatter color* because the light wavelengths are scattered by iridescent surfaces. This effect is achieved in painting by the layering of colors or using all light-value colors that have subtle hue differences, such as pastel colors.

Color and Space

Color adds another level of complexity to the creation of a spatial illusion. To produce a spatial illusion chromatically, there should be a perceptible light source on all three-dimensional forms to give them volume. In a spatial illusion, colors must change in value and saturation as they recede into illusionary space. [10.20] When consistently applied, two specific value and saturation strategies will effectively depict space; colors can be sequentially lightened or darkened but usually should be muted somehow in order to recede spatially. In a "daylight" picture, the background should be paler and lower in color saturation than the foreground. The colors in a pale-background spatial depiction should lighten in value as they recede into the imaginary "space." [10.21] Bright, highly saturated colors advance spatially. For this reason, foreground areas should be stronger in saturation, contrasting in value, very defined, or textural. Muted, low-saturation colors recede spatially, duplicating reality by a sequential graying of color caused by the atmosphere. For this reason, distant background areas should be lower in chromatic contrast. Distant mountains, for example, seem to lose their color as they recede toward

Figure 10–20 Some ways that color can gradate in order to appear to recede into space. Clockwise, from top left: Yellow is muted by the addition of its complement of violet, green is dulled by additions of gray, red is shaded in steps, and blue is tinted in steps.

the horizon. A second value strategy is used for a "nighttime" setting that depicts spatial depth into darkness. To achieve this, light foreground items can gradually become darker and less saturated as they move back into space, enhancing a spatial illusion. [10.22]

Colors should be lowered in saturation to depict space by using a series of tones or chromatic neutrals as an effective way to formulate *color atmosphere.* [10.20] Color atmosphere can be made not only with opaque color but also with *film color,* meaning color that we see through as a filmy transparency like a watercolor or glazes of oil, instead of being opaque, like surface color. Pure, high-saturation colors advance spatially, and duller, low-saturation colors tend to recede spatially. A traditional color space may also employ color temperature to define foreground and background. A traditional perception that warm colors advance and cool colors recede can be applied by "cooling" color temperature along with lowering color saturation to enrich spatial depth. Warm colors and/

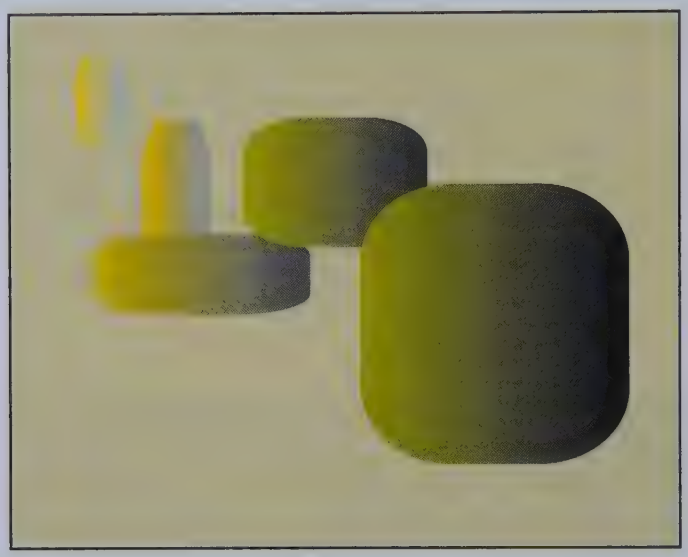


Figure 10–21 Space can be established by giving the illusion of recession into light by sequentially lightening and lowering the saturation of colors (dark into light).

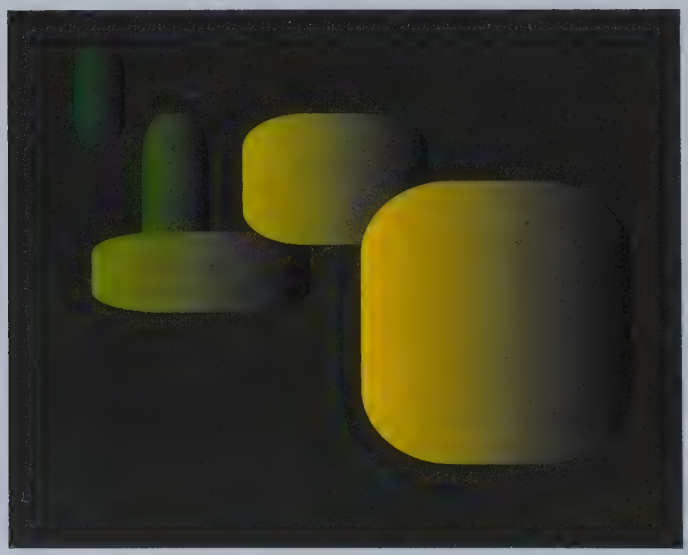


Figure 10–22 Space can be established by giving the illusion of recession into dark by sequentially darkening and lowering the saturation of colors (light into dark).

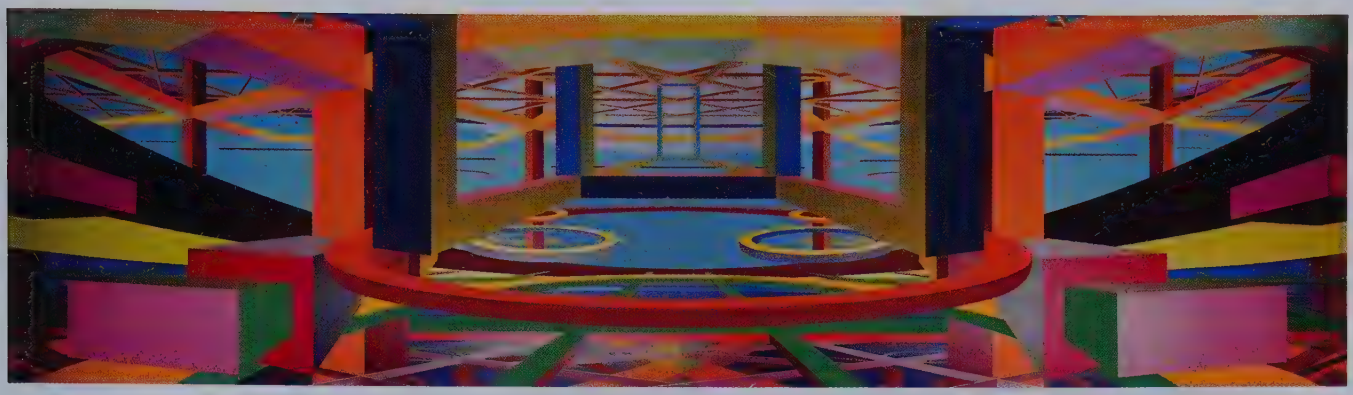


Figure 10–23 *Mantegna's Edge* (1983), Al Held. Acrylic on canvas, 174" × 634". Gift of the New York Life Insurance Company. Boca Raton Museum of Art Permanent Collection, PC 1994.220. Al Held Foundation/Licensed by VAGA, New York, NY. Al Held Foundation/Licensed by VAGA, New York, NY. Al Held forms volumetric shapes with planes of color, suggesting space through varied color saturation along with perspective and diminishing scale, using both space and light to portray a powerful spatial illusion.

or light values can also heighten the impression of light on an object. Cool colors and/or dark values magnify the illusion of shadows.

Light and Color Atmosphere in Abstraction

Depiction of form and light through color is not limited to representational art. The illusion of luminescence, light, and spatial depth is frequently used as a device in abstract and nonobjective painting. Abstract forms can be painted with the illusion of a light source. Color atmosphere is established by the use of luminous colors seen in the atmosphere at varying times of day, colors that are transmitted through transparencies, or masses of color that appear to be reflected from brightly lit surfaces. A luminescent quality may arise from heightened cool/warm contrasts and contrasts of value and saturation. The Cubists and Surrealists, for example, were fond of using color and value gradations to enhance volumes. [12.9] [9.1] In this painting by Al Held, space is established through the powerful illusion of linear perspective, overlapping and diminishing scale. To strengthen the illusion of abstract forms receding in space, the color is progressively lighted in value and lowered in saturation. Even though the geometric volumes are painted crisply, the distant shapes seem to dissolve into the abstract distance. [10.23]

COLOR RHYTHM AND MOVEMENT

Rhythm and movement can be articulated with color by repetition through lines, shapes, or marks to convey kinetic properties. An internal compositional rhythm produced by a system of repeated colors causes the eye to travel throughout a composition. Optical movement is formed from a juxtaposition of opposing hues (complementary vibration), color gradations, or alternating colors or color patterns. Marks, gestures, or repeated motifs in color also enhance a sense of movement. The Imperial Vault of Heaven is part of a large temple complex in Beijing China. In a beautiful circular structure (which symbolizes heaven), the interior of the dome and the entire inside of the building are covered with an elaborate all-over pattern. The building was a place of worship for the Gods of agriculture, earth, and water. The interlocking patterns produce a color rhythm, punctuated by the red columns and elaborate surface motifs, giving the structure an all-over richness, and a sense of rhythm and movement. [10.24]

Color rhythm can also be emphasized by a systematic repetition of color as in the painting *Deposition* by Van der Weyden shown in [9.18]. Here, the drapery of each garment provides a color rhythm of red, gold, and blue across the altarpiece, also articulated by the rhythmic structures of the curved figures themselves. Gestural marks can also purvey a sensation of speed through the character of paint application and

Figure 10–24 Interior, *Imperial Vault of Heaven* (Huang Qiong Yu), Temple of Heaven, (Tiantan) Beijing. This structure was built in 1530. Here the tablets of the emperor's ancestors were kept. Photo: Vanni, Art Resource, New York. Temple of Heaven Beijing, China. The polychrome, painted motifs on the interior of this dome are an example of rhythmic color and pattern.

brushwork; small marks or lines of vibrating colors cause vibrant optical effects. [4.28] [11.7] Optical kinetic effects that are based on the perception and knowledge of optical mixtures are simultaneously exciting and disturbing.

Color unity, emphasis, weight, contrasts, space, and movement are all factors in the placement of color in a composition. A thoughtful placement of color can generate emphasis, cause the eye to move, and finely balance or solidly unite a composition.

Activities

1. Color Emphasis Study

Objective: The student will create one or more point(s) of emphasis both compositionally and with color.

Media: Colored paper on board.

- This study involves an organic shape or a shape derived from a man-made shape. Design a composition using the shape flexibly in the picture space, using repetition with variety.
- For variety, the shapes can have varied scale, also using the shape's parts.
- Do not create a traditional pictorial composition. The shape should be positioned for design purposes regardless of any subject.
- For variety, use overlapping and make sure that both the positive and negative spaces are well designed. The composition may have large or small areas of negative space.
- One area of the composition should be established as a point of emphasis. Remember the techniques for creating emphasis: isolation, types of color contrast, and also contrasts of scale, position, and direction.

Figure 10–25 Color emphasis study. Student work by Laurie Stahrr.

- The color scheme is a group of two to three analogous hues, such as red, RV, and RO along with the tints, shades, and tones of these hues. Make sure that the point of emphasis is reinforced by color.
- A color, size, or position gradation can also be used to direct the eye to a specific point in the composition. [10.4] [10.25] [10.11] [10.10]

Additional Emphasis Study

- Use any of the formal color schemes in Chapter 9: complementary, split complementary, triad, tetrad, monochromatic, or analogous, along with Itten's types of color contrasts from this chapter to create a piece from found, computer-generated, or painted color areas to make a piece with a point of emphasis.

2. Color Balance Studies

Objective: For the student to demonstrate knowledge of compositional and color balance by working from an asymmetrical, symmetrical, or radial compositional model.

Media: Colored paper, paint, or computer illustration mounted on board.

A. Asymmetrical composition

- Line, shape, form, texture, or space may be used to execute this study. Choose one to three of these elements.
- Shapes may be invented or symbolic, but the overall composition should be nonrepresentational.
- Draw a horizontal, vertical, or diagonal axis through the center of the composition before you start. This will help to assess balance.
- Create a composition that takes an asymmetrical balance risk. Make at least three compositional sketches in colored pencil for a composition that has more visual weight on one side of the axis.

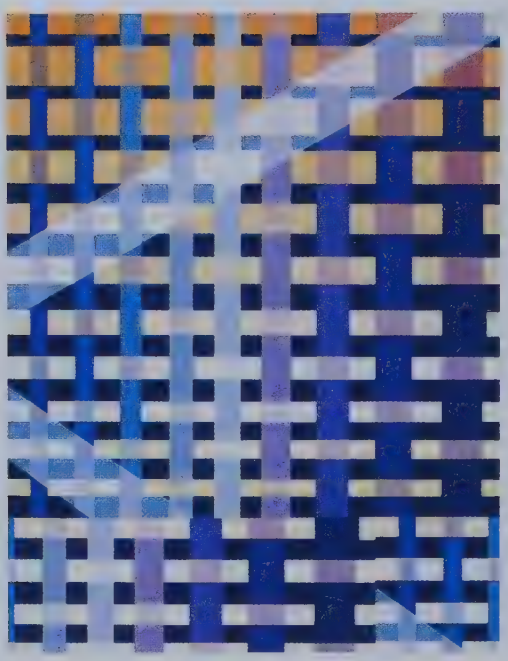


Figure 10–26 Color asymmetrical balance study. Student work by Simone Theriault.

- Manipulate the elements and colors that have visual weight: forms, complexity, dark values, high-saturation colors, textures, and so on.
- Using a formal or informal color scheme, try to balance the composition with color. [10.26]

B. Symmetrical composition
- For this composition, divide the picture area with an axis, as in A (above).
- Design a perfectly symmetrical compositional structure. Make several different sketches of symmetrical compositions, varying the positioning of the axis.
- Use colored pencils to plan color on one of the sketches using color scheme. [10.15]
- Use the relative weight of colors to "unbalance" the composition by color placement. Using the symmetrical composition, place the colors in such a way as to create a feeling of asymmetry merely by color placement. Keep in mind the relative weight of colors and color contrasts.
- This study can also be executed easily on the computer, using shape tools and copying, mirroring, and pasting half of the composition. Colors can then be readily changed from one side of the axis to the other.

C. Radial Balance Study
- Make a composition with radial balance. Radial balance has sequential components, radiating from one or more parts of the composition.
- A hue, value, or saturation should gradate from one or more points in the composition. Colors may gradate from light to dark, from brighter to duller, or chromatically from the main point(s) of the composition. [10.4] [10.16]

3. Color Space Illusion Study

Objective: The student will use both perceived and invented color to create form and space in color.

Media: Choice of colored paper, collage, and/or paint on board.

- Start with one or more invented or geometric shapes. Make sure that they have volume.
- Create depth by repeating the shapes and diminishing the scale. You may use any of these three formats: a linear perspective interior, an architectural exterior, or a

Figure 10–27 Color spatial illusion study. Student work by Branden A. Kautz. Courtesy of Becky Koenig.

ground/sky plane. You may also float overlapping forms in a spatial environment for your shapes.

- The composition should have a foreground, middle ground, and background. It should be imaginative rather than realistic.
- You may choose your own colors, but keep in mind the color and spatial guidelines that follow.
- Pick a group of colors, using a formal or informal color scheme.
- The shapes should have some sense of a light source. [10.27]

Guidelines for Creating Depth in Color

A. Foreground should:

- Have large-scale items.
- Have more highly saturated colors.
- Have more detailed items.
- Have light-value objects if background is dark and dark-value objects if background is light.
- Use warm colors, which appear to advance spatially.

B. Background should:

- Use diminishing scale.
- Have less detail.
- Have less value contrast.
- Have less-saturated colors.
- Use cool colors, which appear to recede spatially.
- Let items get darker as they recede into a dark background.
- Let objects become lighter as they recede into a light background.

C. Remember to:

- Pick the value of your background first.

Glossary

Chiaroscuro A technique of high contrast lights and darks in painting, notably in the Baroque period of European Art.

Color Contrast As defined by Johannnes Itten, color can contrast in the following ways: hue, value, saturation, and temperature. Understanding color contrast is a key to creating color emphasis and unique color as well as manipulation of color weights compositionally.

Color Space Illusionistic devices of color that enhance atmospheric perspective, light, and form.

Color weight The visual weight of colors is relative to their interactive color environment. Some colors are innately heavy or inherently light in weight. For example, yellow is light and black is heavy.

Chapter 11

Expressive Color

LEARNING OUTCOMES

- To understand the emotional content and expressive quality of color.
- To understand and use color symbols, both cultural and personal.
- For the student to begin to create a group of personal or "signature" colors.
- The color associative process: learning to establish meaning with colors and visually communicate through color.

INTRODUCTION

Color theory concepts, art elements, and design principles are the purely visual components of art known as *formal* elements of art and design. *Form*, however, is only one component of the three aspects of art: form, history, and content.

The *content* of art encompasses several ideas: *subject matter* (what a work depicts), *iconography* (the symbols present in a work), and *theme* (the ideas behind the work of art). Color, due to its complexity and human associations, can function in either a formal or an expressive mode. The expressive quality of color can impart content to a work of art.

The viewer responds to the colors of an artwork based on his or her personal, cultural, environmental, symbolic, and psychological preferences. The collective unconscious mingles with our experience of the world to influence these color preferences. The term collective unconscious had its origin in the theories of Carl Gustav Jung (1875–1961), a Swiss psychiatrist who separated the concept of the personal unconscious from the collective unconscious. He defined the *collective unconscious* as the inner feelings, thoughts, and memories that we all inherit and share as human beings. Our personal color preferences are often guided by these types of internal instincts rather than by rational color systems. Color is an effective tool of visual communication because it is an essential part of our psychological makeup.

In its role as the most expressive element of art that is available to the artist, color is also the art element most enriched with associations. Color plays a role in cultures worldwide, aesthetically, symbolically, and through the media.

COLOR PSYCHOLOGY

Psychology can be broadly defined as the science of the conscious and unconscious mind and of mental functions, behaviors, feelings, and dreams. Color is an external visual experience, but also part of our psychological makeup. Our ability to respond emotionally to color, and our capacity to visualize color internally, demonstrates that color is part of our psyche. For human beings, color is both a physical and an emotional experience.

Color is directly interconnected with light because it is a component of light, and our color perception depends on and is activated by light. The effect of light on our psychological and physical well-being is profound. The amount, type, and variation of light in the day/night cycle and throughout the seasonal year are closely tied to human life. Light determines our pineal and endocrine functions as well as our behavior, sleep, and metabolic patterns. It has an acute effect on our cognitive and emotional well-being. In sunlight, there is a balanced array of spectral colors that enter our body not only through our eyes but also into our skin through UV rays (hence, our fondness for sunbathing).

Our visual sense is a conduit that connects the external world to our inner mind and psyche. Color associations are thought to be embedded in our collective unconscious upon birth. A factor in our color likes and dislikes is our personal history with color. Color preferences can be rooted in childhood and life experiences with certain foods, toys, picture books, and special places. [11.1]

Color psychology has been studied by experimentation that documents human reactions to strong colors and color environments. Studies have been conducted to document common human reactions to hues and neutral colors that support our understanding of color and human response. Specific colors have provoked similar human reactions through a cross-section of people and cultures.

Throughout human history, the notion of physical reactions to individual colors has been utilized for healing physical ailments. The Egyptian physicians prescribed colored minerals such as malachite (green) or red and yellow ochres to heal various maladies. The Greeks employed color along with music and poetry to assist healing. Colored plasters for wounds were used by the ancient Greeks to speed healing. The Greek Claudius Galeneus (A.D. 129–199) framed classic human personality types based on color associations: choleric—red (angry), sanguine—yellow (calm), melancholic—blue (depressive), and phlegmatic—green (stoic and self-possessed). Red continues to be associated with anger and "the blues" with sadness. The physician and philosopher Ibn Sina (A.D. 980–1037) of Persia found that red light stimulated the movement of blood and blue light slowed it, findings that still have merit today. Dr. Edwin Babbit wrote the *Principles of Light and Color* in 1878, in which he described his color therapy or "chromotherapy" for various illnesses. He used yellow and orange, for example, as nerve stimulants. Chromotherapy is still practiced in some countries, outside the United States.

Research has been conducted to study human reactions to various colors by exposure to colored light or environments. When colored light was projected into the eyes of human subjects, color-specific responses were recorded. Red light was found to be

Figure 11–1 Our color preferences may be rooted in experiences of special things and places. Courtesy of Becky Koenig.

arousing because it increased blood pressure and quickened the pulse. Yellow felt sunlike to the subjects and provoked nervous responses, elevating their activity level. Blue-violet was pleasant and calming and elevated concentration levels of the subjects. Green was also calming, with an overall positive effect.

Color responses also have been measured by situating human subjects in highly saturated colored rooms. Subjects in a red room found the color overstimulating, and red heightened both blood pressure and pulse levels. A blue room lowered blood pressure and slowed the activity of the subjects. A yellow room had no effect on the subjects' blood pressure but caused eyestrain. A green room caused no physical reactions and was considered a calm but monotonous environment by the subjects. All these reactions were based on exposure to pure intense hues. Less intense versions of these hues (lower in saturation or different in value) provoke similar but less strong responses in the viewer.

Color association often engages other senses in addition to our visual sense. For instance, some colors trigger associations with food and our sense of taste, such as candy colors: mint green, candy apple red, or bubble gum pink. Food references are directly used in descriptive color names such as pumpkin, persimmon, tomato, tangerine, and celery. [11.2] Color is often described in terms of sound or music, forming analogies between color and the aural sense. For instance, colors are considered to be loud, soft, quiet, harmonious, or discordant. There are tactile associations between color and texture; earth reds or yellows can be thought of as dry colors and blues, greens, or grays as wet colors. The association of color with other sensory objects is part of synesthesia, the simultaneous response of two or more senses to a single stimulus.

We readily connect conceptual ideas with particular individual colors. When subjects were asked to link colors with specific concepts, for example, they tied love to red and red-violet, hate to black, peace to blues and greens, and happiness to yellows and oranges. Generalized associations with specific colors are revealing: Green is thought to be relaxing, refreshing, and quiet but also is linked with illness and poison. [11.3] Blue is affiliated with calmness, contemplation, and yearning, but also with melancholy. Red is erotic and conveys excitement as well as pain. [11.11] Violet is connected to dignity, magic, and royalty but is also mournful. Orange is stimulating, extroverted, and suggests sunsets and sunlit rocks. Brown is comforting, conveying earth, wood, and warmth. Yellow is luminous, hopeful, joyful, and warming. White stands for light and hope. Black conveys evil, darkness, but also formality. Gray signifies the calm and conservative. Colors have also been associated throughout time with gender, notably by the artists of The Blue Rider, an art movement in Germany formed in 1911, which led artists like Wassily

Figure 11–2 Color is also associated with music, sound, or tastes; candy colors are "sweet"; colors are also named after many foods such as "tomato red." Courtesy of Becky Koenig.

Figure 11–3 Green is considered a calm, relaxing color. Courtesy of Becky Koenig.

Kandinsky and Franz Marc to associate blue with the male and yellow with the female. Marc's words on this association: "Blue is the male principle, sharp and spiritual, yellow, the female principle, soft, cheerful and sensual, red, the material, and ever the color which must be resisted and overcome by the other two!"

COLOR SYMBOLS

The symbols, or iconography, of particular colors that communicate definite meanings, have been utilized throughout art history. Color iconography is based on cultural or universal factors. Red for sexuality and black for death are examples of culturally based color associations. Other color symbols are cross-cultural or universal—for instance, gold or yellow often symbolizes the concept of the celestial, heavenly, or spiritual, as seen in the walls and decorative elements of the Temple of Heaven in Beijing, China. [10.24].

Some color symbols span cultural boundaries to symbolize similar ideas. Some meanings of traditional Western or cross-cultural color symbols are listed as follows:

	Western	Cross-Cultural
Red	Blood	Fire
	Martyrdom	The sun
	Sin	Sexuality
	War	Evil
	Anger	Fertility
		Masculinity
		Festivity

	Western	Cross-Cultural
Yellow	Treachery	Spirituality
	Cowardice	The sun
	Light	Gold
	Truth	Radiance
	Warning	Earth
	Cheerfulness	
Blue	Heaven	Coolness
	The celestial sphere	Eternity
	Water	Faith
	Baptism	Serenity
	Space	Wisdom
		Feminine
Green	Spring	Holiness
	Resurrection	Charity
	Envy	Regeneration
Black	Death	Sadness
	Evil	Mourning
	Darkness	Time
	Void	Rebirth
	Witchcraft	
White	Light	Death
	Air	Redemption
	Purity	Innocence
	Marriage	Surrender

Throughout history, artists have manipulated colors in a manner that connected to their own cultural iconography and historical context. Color symbolism may also be indicative of a specific period of art; for example, the Virgin Mary in medieval, Gothic, and Renaissance art was often portrayed wearing a blue robe, symbolizing her heavenly or celestial presence.

To symbolize the virginity and unspoiled youth of a woman, a Western artist might portray her in delicate whites. In contrast, in Asian culture, a woman in white might be in mourning, since white symbolizes death and rebirth in Asian cultures.

Graphic designers exploit our bias toward color symbols. Advertisements for new cars, for example, often illustrate the new vehicle models in bright red, which, in addition to being eye catching, convey a cultural color message of power, heat, and masculinity. In communication design, designers manipulate color symbols to create consumer desire for and to promote a product. Selection of color is a critical part of design that conveys a product-specific message to the consumer. For instance, the color of package design for a fragrance might be a pale blue-green, and the packaging of a power tool could be red and black.

Echoes of Techno, a concert poster designed by Swiss designer Nicklaus Troxler, has clear-cut color and value contrast that emphasizes the banded format of the composition. The overall compositional structural motif is reminiscent of both bar codes and digital circuitry. In this way the designer communicates a technological feel through color and form, integrating the text into the compositional structure to communicate visually. [11.4]

ENVIRONMENTAL COLOR

A principal way that we visually identify objects is in relationship to their environments. For example, animals either stand out in color contrast or visually intermingle with their

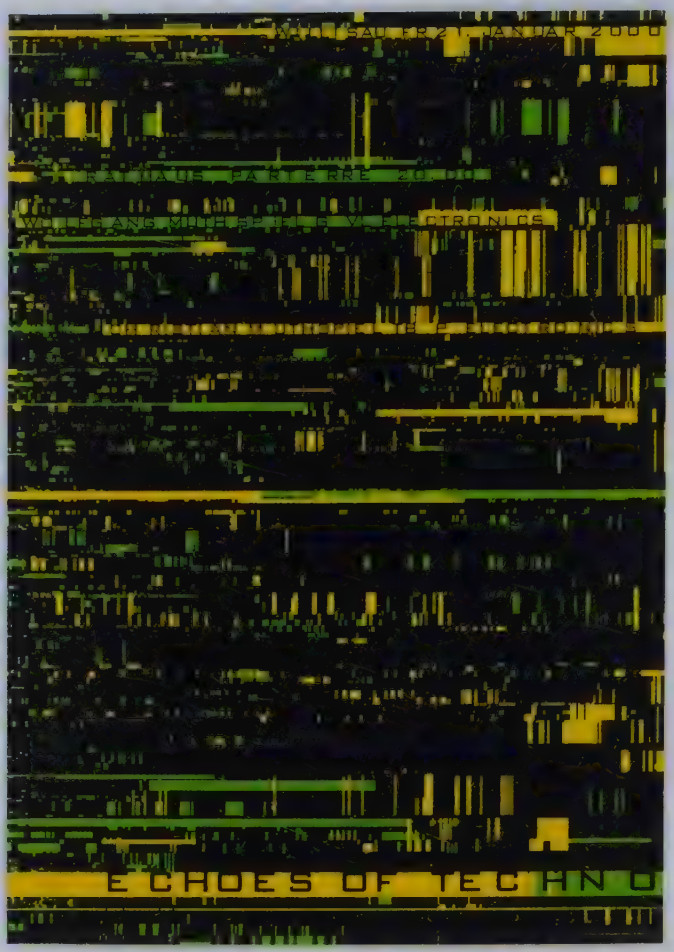


Figure 11–4 Designers use color symbols to enhance the communicative nature of graphic design. *Echoes of Techno,* Niklaus Troxler. Printer: Siebdruck Bosch AG, Luzern. 2000. Silkscreen, 35-5/8" × 50-3/8" (90.5 cm. × 128 cm). Gift of the designer. 480.2008. Museum of Modern Art/ARS, NY. © 2011 Artists Rights Society (ARS), New York/ ProLitteris, Zürich. Photo: Scala/ Art Resource, NY.

environmental habitats. Brightly colored birds, such as red cardinals, contrast with their environment to conspicuously identify their territory. Other animals adapt to their environment by colors and textures that camouflage them, like a rattlesnake with a texture and color that blends with its desert environment of gold and brown. Human beings use color perception to identify warm-colored fruits like raspberries or apples that stand out against the complementary green of the surrounding foliage.

We can derive color associations from our physical environment. An urban, northern, tropical, or arid environment suggests a correlating color personality. For example, an arid environment can be articulated by earth colors—oranges, reds, and browns. Colors can be affiliated with each season: winter with blues, grays, white; spring with light-value colors such as pale greens, yellows, pinks; summer with highly saturated greens, blues, reds, yellows; fall with brown, oranges, reds, yellows.

Environmental designers are sensitive to colors that reflect and enhance the function of an interior space. A place of worship such as a temple or a church may not be the appropriate place for large expanses of very high-saturation warm colors such as red or red-orange because they stimulate and warm us, increasing our blood pressure. Meditative colors such as blues, neutrals, greens, and violets may be more fitting choices for a house of worship.

Architects often refer to nature as a color inspiration for their building designs, which can visually unify a building with its geographical site. Color temperature factors in to environmental color design as the climate of a site is often reflected in the design of a building and its colors.

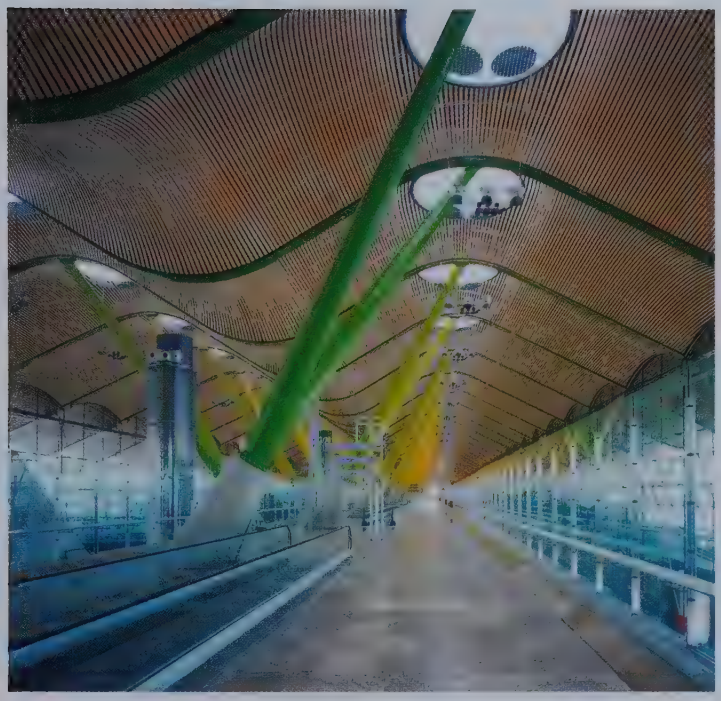


Figure 11–5 The interior of the new Madrid airport incorporates natural materials and brilliant spectral colors into the interior spaces. Barajas Airport Madrid: Madrid Airport building, Spain, Europe Architects: Richard Rogers Partnership with Estudio Lamela. © View Pictures, Ltd./Alamy.

Color in architecture is often a result of the choice of man-made or natural materials. The airport design in Madrid incorporates the landscape and the process of air travel into the design of the building. A sequence of light filled "canyons" brings light inside the structure of the building and divides the functional areas of ticketing, check in, security, etc., inside the space.

The interior finish of a wavy roof made of bamboo, brings in the color of nature inside a normally industrial structure. In addition to this, the architects have created structural columns that they refer to as trees, which are in a sequence of graduated spectral color. The warmth of the colors and light in the spaces reflect the colorful culture and nature of Spain itself, integrated into this award winning design. [11.5].

COLOR HARMONY VERSUS COLOR DISCORD

Formal color harmonies are a reliable mode of color selection, but artists often prefer to organize colors subjectively. Formal color schemes are restricted to specific hue choices, unlike subjective or expressive color, which lacks formal color "rules." An intuitive approach to color frees the artist to devise personalized color harmonies. Artists working with subjective color refine their color instincts, founded on color experimentation, color associations, personal color symbols, and preferences.

Color preferences inform personal color harmony. Harmonious colors produce a pleasing visual experience for both artist and viewer, causing a *positive visual effect.* In contrast, color discord denotes color combinations that produce a *negative visual effect.* A color combination that contrasts, clashes, or "fights" rather than harmonizes is known as *color discord.* A color discord is a color dissonance similar to the purposeful dissonance caused by the harsh, strong combination of notes in a musical composition. In a similar fashion, a visual artist uses color discord to produce unease in the viewer, perhaps to enhance a powerfully negative or disturbing theme. For example, the *Untitled* painting shown here by Jean Michel Basquiat [11.6], an American artist of Haitian and Puerto Rican descent, displays his roots in the graffiti art movement of the late 1970s in New York City. Basquiat, an artistic prodigy, was an Expressionist

Figure 11–6 *Untitled* (1981), Jean-Michel Basquiat. Acrylic and mixed media on canvas. 81' × 69-1/4'. The Eli and Edythe L. Broad Collection, Los Angeles. © 2011 The Estate of Jean-Michel Basquiat/ADAGP, Paris/ARS, New York. Photography credit: Douglas M. Parker Studio. The strident color combination of pure hues, pastels, and dark-value colors sets up a certain amount of color discord or dissonance, which creates unease in the viewer.

painter of the 1980s, with a political and autobiographic perspective to his work. His paintings have a bold Expressionist slant on color, with purposefully crude brushwork. This painting of a skull has a strong color dissonance of blue, red, orange, and black, combining disturbingly high-saturation, harsh colors with pale, delicate ones in an arresting contrast. The overall quality of controlled chaos and powerful style of painting imparts both a stimulating yet discomfiting effect on the viewer. Another artist could use the same theme of chaos and express it in a completely different personal color dissonance.

There are no set guidelines for discordant color combinations. However, strong value, hue, and saturation contrasts, singly or combined, create a discordant effect. Analysis of color discord, like that of personal color harmony, is highly subjective. This is the nature of color expression.

COLOR PREFERENCE

Like everyone, the artist has "favorite" colors. An individual's preferred colors can be one particular hue or favored color juxtapositions. Color preferences are based on personality types, culture, inner psychology, the subconscious mind, the physical environment, and past color associations. The colors that we wear, the colored objects we buy or collect, or the colors we choose for our home environment are all manifestations of

Figure 11–7 Signature colors are a group of individualized colors that express the personality.

our color preferences. Personal color expression can begin with an analysis of our color preferences through an examination of favored colors and color groups.

Johannes Itten employed a color exercise at the Bauhaus School to focus students on personal color choices. The students formed these studies with paper or paint, making a set of individualized, personally significant colors. Through this exercise, students generated a group of colors, directly indicative of their personality or character. The first step in this practice is the selection of preferred primary, secondary, tertiary, or neutral colors. Light, dark, saturated, and unsaturated variations on these hues (totaling ten or more) can then be made from colored pencils, paint, markers, or colored papers, or can be printed digitally. Often, our preference for a particular attribute of colors, such as light values or muted tones, can be as significant as our choice of hues. A personalized group of harmonious colors collectively forms our *signature colors.* [11.7]

COLOR EXPRESSION

Through the filter of our color selections, cultural, symbolic, and personal themes can be expressed. Instinctive color has an inner rather than a formal logic. Many times colors just "feel" right for a particular subject matter or design. Color iconography is personal as well as cultural. An artist may base color selection on subjective experience, and through the development of personal color symbols, an artist might use yellow for love and black for purity. Some key periods and styles of art were instrumental in freeing color from representation to expression. The Neoimpressionists (Postimpressionists) Paul Gauguin and Vincent van Gogh liberated the use of color for expressive purposes rather than to depict accurate retinal perceptions of the external world. The Fauves later expanded on color expression, notably the painters Henri Matisse and Andre Derain. Expressionist artists also explored personal color, including Edvard Munch, Gustav Klimpt, and Egon Schiele. A common ideal upheld by these artists was self-expression through color. Expressionist artists sought freedom from perceptual color, applying a color sensibility to enhance personal aspects of their inner reality and substantiate their subjects and themes. In this way, individualized interpretation of color paved the way from representational to nonrepresentational painting.

A juxtaposition of high-saturation colors is not always disturbing, shocking, or discordant. In Van Gogh's painting *Gauguin's Chair*, blue-green and earth red contrast to emphasize his commentary on the artist Paul Gauguin's personality. [11.8] Van Gogh's color choices were based on his "portrait" of Gauguin through the depiction of his empty chair. The dramatic color shifts, and images of a candle and French novels are meant to convey the essence of Gauguin's powerful and dynamic personality.

Figure 11–8 *Gauguin's Chair* (1888), Vincent van Gogh. Oil on canvas. Van Gogh Museum, Amsterdam. Vincent van Gogh Foundation. Van Gogh Museum Enterprises bv. The chair depicted is meant to be an expressive color "portrait" of Paul Gauguin.

FREE-FORM COLOR HARMONY

Since expressive color has no formal rules, how can color intuition and expression be learned? Some exercises in associative color are a good starting point; the first exercise is a simple, "free-form" color study that provides the student with the experience of communicating emotionally through color.

When we work with meaning—conceptually—this entails linking ideas to visual forms. Free-form color harmonies directly link color with specific concepts. We can begin simply, with a list of verbal/conceptual opposites to serve as a springboard for the process of color association. A basic form of color association connects a group of harmonious or discordant colors with each verbal idea to familiarize us with color communication. [11.9] A sample list of visual/verbal opposites follows.

Visual/Verbal Opposites

Bright–Dull	Close–Far
Night–Day	Ordered–Random
Morning–Evening	Light–Heavy
Light–Dark	Stationary–Moving
Uniform–Gradated	Open–Contained
Expanding–Contracting	Cold–Hot
Simple–Complex	Wet–Dry
Natural–Technical	Crude–Refined

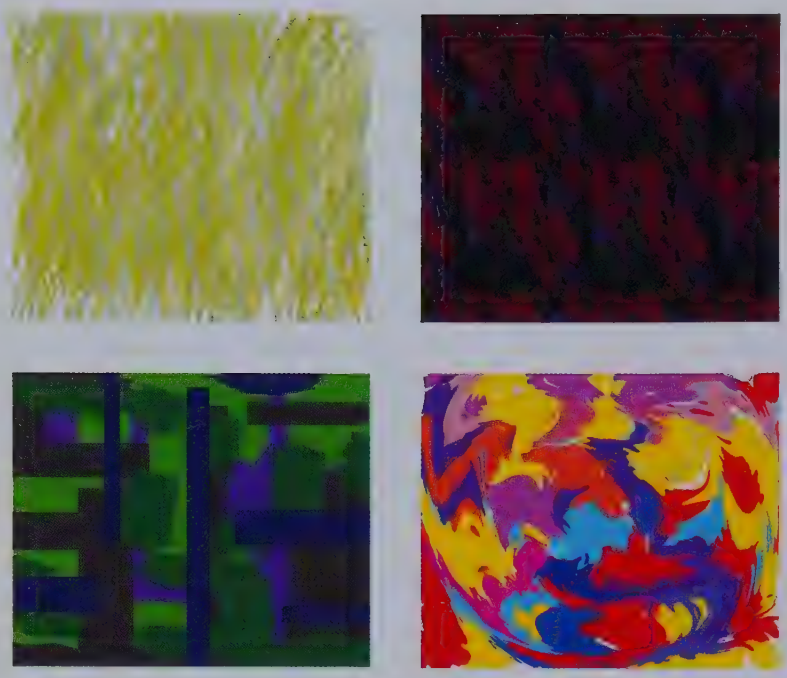


Figure 11–9 Part of free-form color study is selection of colors that illuminate specific concepts for color expression. Top: color selections for the words *light* (left) and *heavy* (right). Bottom: *stationary* (left) and *moving* (right).

In this exercise, the formal choices of two to ten colors are directly tied to the meaningful verbal/visual concept. For example, the word "simple" might be associated with a group of primary hues or a monochromatic color scheme, as they are simple color groups. On the other hand, the opposing concept, "complexity," may correlate with a wide range of full saturation colors. A second step in this exercise prompts a synthesis of a vocabulary of lines, marks, media, texture, scale, or shapes that correlate with each verbal concept. [11.10] Color used in either abstraction or image-based art provokes meanings and symbols.

THEMATIC COLOR

Art can represent virtually any subject matter or idea in a visual format. The content of art consists of its subject, underlying theme, and iconography (symbols). Subject matter

Figure 11–10 Free-form studies based on the words *cold* (left) and *hot* (right). Paint, collage, and assemblage. Student work by Bonnie Sue Bacon. Courtesy of Becky Koenig.

in art is what is perceptually evident in an artwork. In other words, the subject of a piece of art refers to what is obviously depicted—a house, a face, or lines and shapes. *Traditional subjects* of perceptual art are the human figure, portrait, still life, and the landscape. *Conceptually based art* differs from perceptual art because it starts with ideas: our inner world of feelings—our dreams, our ideas—expressed about the world, rather than depicting the outward appearance of things. Conceptually based art ranges widely in subject: distortions of reality, expression of inner thoughts, fantasy or dream images, formal subjects such as texture or line, unconventional views of everyday life, and ideas about political or gender subjects. Color is a vehicle that can influence our perception and convey the underlying theme of an artwork.

This portrait by the American artist Cindy Sherman (1954–) is one in a series of photographic portraits. Sherman's oeuvre consists of thematically based groupings/series of self-portraits in which she presents herself in many guises and alter egos. In her clown series, Sherman wears almost painfully garish makeup, costumes, and background colors and poses in a clown's funny yet melancholy persona. [11.11] This image has a male and a female clown (both the artist), which "bookend" the overall piece, and the two figures are physically and emotionally isolated in their own spaces. The colors are full-out, saturated, spectral "rainbow" colors associated with the circus, which exaggerate the essential discomfort of the figures. One of the most interesting aspects of this piece is the subversion of colors that we usually associate with a childlike positivity. The spectral hues are almost clumsy in their capacity to intensify the grotesque quality of the clowns.

Figure 11–11 This photograph by the artist Cindy Sherman has brilliant pure color that nonetheless expresses the innate unease of the clowns. *Untitled #420* (2004), Cindy Sherman. Color photograph 75-5/8" × 94-3/4" overall. The Broad Art Foundation, Santa Monica, Calif. Courtesy of the artist and Metro Pictures.

The theme of an artwork is distinct from, yet inextricably connected to, its subject. A theme is the underlying idea in an artwork: its inner statement of meaning. For example, if the subject matter of a painting is a deserted street, the theme of the piece could be human alienation. The thematic content of art touches upon the environmental, political, sexual, universal, or spiritual aspects of living. A theme can address any aspect of life visually conveyed in a functional or aesthetic manner.

The inner message of an artwork can be gleaned from discrete visual hints provided by the artist. An artist supplies visual clues that may be in the subject, symbols, style, media, and color qualities or an artwork. Thus, a theme generates a statement about emotional states, social issues, human characteristics, spirituality, and everyday situations.

In Henri Matisse's *The Egyptian Curtain*, the artist expresses visual exuberance through pure colors that depict sunlight streaming through a window. Matisse's color has a positive impact: the complexity of patterning almost casually combined with a spontaneous painting style. Matisse said of his work, "What I dream of is an art of balance, purity, and serenity, devoid of troubling or depressing subject matter." Matisse's subject matter is a personalized view of everyday life, his theme is joy, and the vehicle of this message is color. [12.8]

Much of the art of Edvard Munch explores an opposite, emotionally disturbing thematic territory. Munch (1863–1944) was a notable Norwegian painter and graphic artist known for his Symbolist and Expressionist works. His paintings consistently exploit color to indicate psychological states. This work *Melancholy* [11.12] depicts his sister, Laura, who was afflicted with mental illness. She stares at the viewer with vacant eyes; the table before her has a pattern of a red motif that suggests a cross-section of the brain. She is bundled in gray clothing; the outside landscape is frigid and painted in cool colors, yet the interior of the room is red and striped with yellow light; a vivid red

Figure 11–12 *Melancholy,* Edvard Munch. Munch Museum, Oslo, Norway. © 2011 The Munch Museum/The Munch-Ellingsen Group Artists Rights Society (ARS), NY. Scala/Art Resource, NY. Munch depicts the theme of melancholy in a discordant combination of warm and cool colors, emphasizing a startling red.

flower grows in a pot on the table. Munch's color sensibility was primarily symbolic; a cold figure enclosed in an ominously warm environment, in turn surrounded by the frigid external landscape expressing the melancholia and confusion of his sister's world.

The separate disciplines of art and architecture often meld perfectly together in thematic content. Art Nouveau was a prominent style of art during the late nineteenth and early twentieth centuries that spanned across disciplines to encompass fine art, graphic art, the decorative arts, and architecture. The example shown is an interior of a hotel in Palermo, Sicily, designed by the architect Ernesto Basile. The hallmark of Art Nouveau is its emphasis on stylized botanical forms, and highlighted curvilinear, sinuous line. Art Nouveau fused natural motifs with interior architectural space and design through surface decoration that was meant to produce a sense of nature in interior spaces. The colors in this decorative mural are muted earths, predominantly soft and warm colors that meld with the natural wood elements of the architecture and furniture. The overall impression of this interior is that of a fanciful, interior garden, with colors that are subdued enough to impart a relaxing effect on the hotel occupants. [11.13]

An artist can communicate any theme by a combination of subject matter, art elements, design, and color selections. The construction of a two- or three-dimensional study based on a specific theme can broaden our comprehension of color expression. Two common thematic subjects are either human characteristics/emotions or cultural/environmental conditions. A verbal list (either individualized or the one provided here) is invaluable to help specify a theme. For this exercise, the student selects a specific

Figure 11–13 Interiors of the hall of the Grand Hotel Villa Igiea. Art Nouveu hall by Ernesto Basile. DeA Picture Library/Art Resource, NY. This Art Nouveau interior has a garden motif and the strong lines that are hallmark of that style.

theme and then brainstorms ideas for the study to stimulate many approaches to the same idea. The formal aspects of this study should be subject to and dictated by the conceptual idea.

For example, the shapes, textures, style images, and colors that are chosen to convey a theme of worship would be diametrically opposed to the visual elements to convey a theme of war. A sample list of themes for an expressive color study follows.

Human States, Characteristics, or Moods

Anger	Serenity	Meditation
Thoughtfulness	Mourning	Whimsy
Greed	Animation	Paranoia
Envy	Tenseness	Victory
Compassion	Obsession	Hostility
Hunger	Callousness	Growth
Confusion	Health	Worship
Lust	Arrogance	Frailty
Alienation	Calmness	Death
Illness	Hate	Love

Environmental and Cultural Themes

War	Pollution	Justice
Peace	Humidity	Celebration
Richness	Urban	Darkness
Austerity	Aridness	Coldness
Silence	Infinity	Oppression
Noisiness	Confinement	Imprisonment
Dirty	Winter	Airy
Cleanliness	Summer	Pastoral
Wealth	Purity	Poverty

To begin a thematic piece, the process of brainstorming is an effective and spontaneous technique for making instinctive color and image selections. The first step is writing or sketching any possible ideas without prejudging their appropriateness. A stream-of-consciousness approach to idea generation can be more effective than laboring pictorially, which often leads to fixing onto a first idea. To articulate a theme through images or abstraction, appropriate words, images, shapes, and colors are selected. Researching an idea with images, text, and symbols is also a critical step toward generating an idea while avoiding literal or clichéd ideas. [11.14]

The last steps in the brainstorming process are selection of an optimum idea from the group of rough sketches and notes, refining the composition, and choosing the formal means: the art elements to be used, such as line and texture, and the media and style of representation. For any theme, color expression should be a major factor, selected from cultural or personal color choices. This type of planning, of course, should be somewhat flexible, because the art-making practice is a process of discovery and change as a piece progresses. However, students have more success when an ambitious piece is planned because idea development and execution is such a significant part of art making.

For example, if a theme of the senses such as hearing/sound is chosen, art elements, words, and images associated with the aural sense can be drawn or written

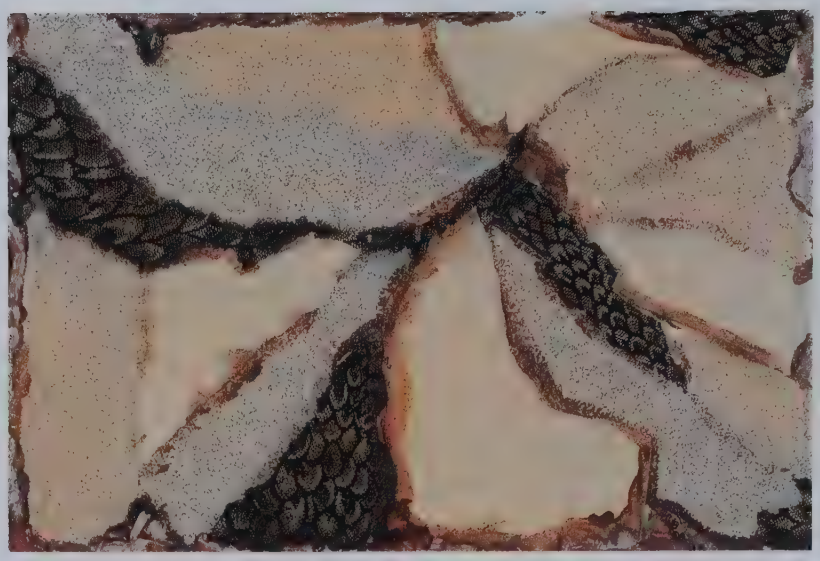


Figure 11–14 Thematic study on the word *arid*: assemblage and paint. Student work by Marlene Shevlin.

Figure 11–15 Thematic study on sound: found objects, paint, and marker. Student work by Brendan King.

down. How can the theme of sound be expressed abstractly or with specific images—by color, mark, shape, and composition? What colors are culturally associated with the idea of sound, or oppose it? A color correlated with sounds could be red, as red may seem to be visually "loud." What colors does one personally associate with hearing or sound? Should color harmony or discord be used to express sounds? How can researched images be gathered and gleaned to find usable visual information? The student example shown here represents hearing/sound and uses materials in an inventive manner. [11.15]

Materials that are found and modified can broaden the language of an artist's expression. Objects, because of their functions and associations, can form potent

Figure 11–16 *Untitled (Paul and Virginia)* (1946–48), Joseph Cornell. Construction, 12-1/2" × 9-15/16" × 4-3/8". Collection of Mr. and Mrs. E.A. Bergman, Chicago, Ill. The Joseph and Robert Cornell Memorial Foundation/Licensed by VAGA, New York, NY. Photo: Edward Owen / Art Resource, NY. Cornell's assemblages used the found colors and images to create visual poetry.

expressions of ideas. One of the seminal artists of the found was Joseph Cornell, an American artist who worked with the "flotsam and jetsam" of life that he found on the streets and in junk shops. With these objects, he either found the colors to express his ideas or he modified them with paint. [11.16] Even though Cornell was not formally trained, he had an eye for personal subtle color harmonies that he cobbled together from his beloved collection of objects. The assemblages that he constructed have the imagination of a rendered work, combined with the resonance of the found object and its color.

The above exercise can be continued by more types of brainstorming—for example, the theme of worship. A list of adjectives or verbs for the word "worship" can then be compiled—for example, spiritual, religious, nirvana, bliss, radiance, heavenly—to assist in choosing specific images that associate with these words. Images extracted from this written list might include skies, flowing robes, clouds, light, luminescence, and reflective gold or silver. A two-dimensional or three-dimensional format can then be determined along with a list of possible media, objects, or textures to communicate the theme. Images do not necessarily have to be locked into a traditional pictorial structure but can be taken out of context and/or juxtaposed. Once multiple ideas have been generated, the piece of art can be executed. [11.17]

Figure 11–17 Thematic study on religion and myth, watercolor. Student work by Charlene Smerden.

Expressive color is highly subjective, entailing a process of personal and cultural self-discovery by the artist or designer. Color expression leads art making away from merely a formal study to the inner world of ideas, symbols, and imagination.

Activities

1. Signature Colors

Objective: To understand one's color preferences and learn to develop a selection of personal color harmonies or signature colors.

- Pick or create one or two groups of colors that form a personal harmony and/or represent an aspect of your personality. Start with several hues and variations or make colors according to descriptive color names. Colors can be pure hues, neutrals, or any variation.
- Use markers, colored pencils, digital color, or colored paper swatches for one or two sets of signature colors with ten colors each.
- Present these color sets in a nonimage pattern, such as stripes or a grid, so that the colors make a statement that is independent of image or composition. [11.7]

Additional Signature Study:

- Use a group of personalized signature colors as a color palette for rendering an image of yourself, a personal object, or a space.

2. Free-Form Color Studies

Objective: This study helps the student discover free association of colors with verbal concepts. Also, the student should to be able to express the idea of visual opposites by color, media, and composition.

Media: Cut or torn papers or paint on board.

- From the list of visual and verbal opposites on page 222, pick a set of opposite concepts, for example, light and heavy. You can start by making a verbal list of colors that

you consider light and those you consider heavy. For example, some people may consider dark shades of colors heavy; others might think that full-saturation colors are heavy.

- The best way to approach this is by an instinctive word/visual association process. Try not to prejudge your choices. Come up with a group of five to ten colors for each concept. Make a swatch of each palette of colors with markers, printed out computer color, or with colored pencil.
- As you create these groups of colors, think in terms of color harmonies or dissonances. Which is appropriate for the chosen concept?
- Free associations can also be utilized to produce some quick sketches that express the concepts with other art elements, such as line, scale, and texture.
- The products of the free associative process can be synthesized into a composition with color, and at least one other design element, such as shape, to fully express the visual pairing.
- There should be one composition per concept and a composition for each one of the pair of visual opposites.
- Visual opposites together in one composition.
- Totally nonobjective or abstract means to express each concept.
- Images to symbolize each concept.
- Simplified or abstracted images to express each concept.
- Remember, in whatever manner the words are expressed, color should be the primary means of communication of each concept in the composition. [11.10] [11.18]

3. Thematic Color Study

Objective: The process here is to use color to express a human characteristic or an environmental or cultural theme. This study is also an exploration of creating a piece in two or three dimensions with color, image, and/or found objects.

Media: Foam board, wood, or illustration board, or a free-standing object constructed with glue. This study may include found objects, painted, and/or colored paper.

- Pick out several themes from the list of human states and characteristics or environmental and cultural themes on page 227.
- Brainstorm images, shapes, colors, symbols, and compositions by a free association process. Take into account personal reactions as well as the cultural views of each theme.

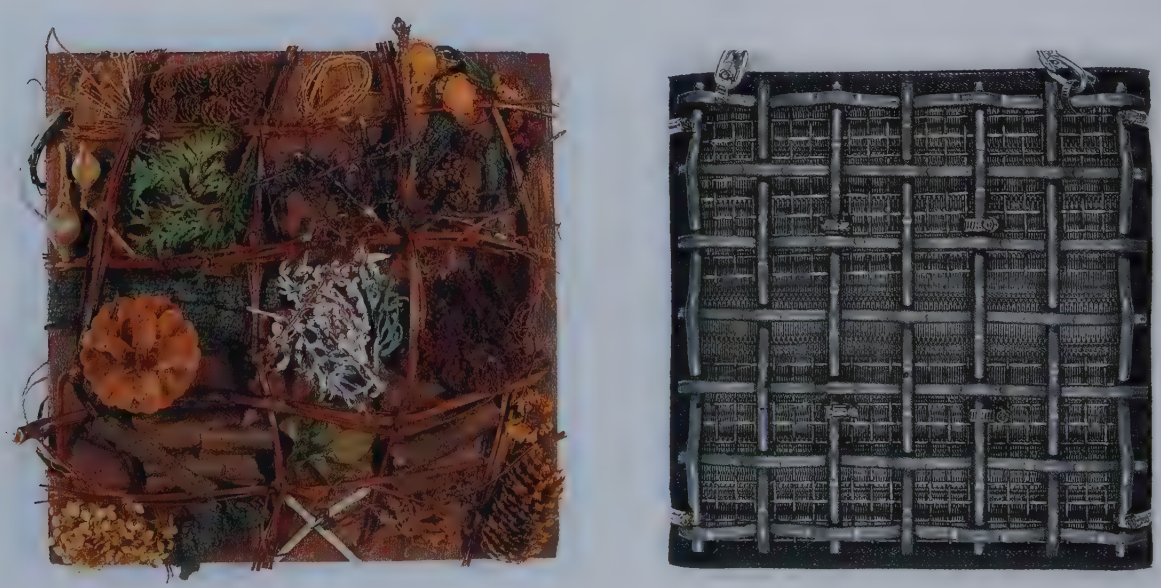


Figure 11–18 Student studies on verbal opposites *organic* and *man-made*. Student work by Laura Shoemaker. Courtesy of Becky Koenig.

- Write lists of ten or more images, shapes, or colors that you connect with each theme. Do some research on the theme that you have chosen, gathering specific images and text and background information.
- Pick the five best ideas from the verbal list and sketch out possible compositions to be executed in two or three dimensions. If three-dimensional, draw top and side views.
- If the structure is complex, make a paper model to prevent any possible structural problems.
- Plan colors that enhance and strengthen your thematic message. If the theme is a negative one, such as war or tension, color discord may be used to more aptly express the theme.
- The final piece should not be overly obvious, clichéd, or appropriated from media sources, but the viewer should have some indication of what theme is being expressed. Imagery should be used in a symbolic fashion to avoid a literal reading of the subject. The structure can be made from wood, foam core, illustration board, or another material. Use hot glue or craft glue. You may use some found objects to enhance your idea. [11.15] [11.16] [11.17] [11.19] [11.20]

4. Color Symbols

A. Identification

- With digital color adjustments, use found or photographed images of objects, places, animals, that are strongly identified by their colors such as a banana, frog, face, and so on. Change photos of these images and color-adjust them to make the colors radically different to change the identity of each object, particularly symbolic objects such as a flag. Make a set of these color-changed images. How have their meanings been changed, and what is our new interpretation of them? [11.21]

Figure 11–19 Thematic piece on the words *nature* and *technology*. Collage, paint, and assemblage. Student work by Molly Maureen Hoelke.

Figure 11–20 Thematic study on nature and technology, paint and mixed media. Student work by Oreen Cohen.

Figure 11–21 By changing an object's color identity or symbol, we often change the meaning and interpretation of an object. Courtesy of Becky Koenig.

B. Communication

- Using the concept of color symbols, design an ad or packaging design for an imaginary product.
- Think about the type of colors and color groups that would be appropriate to the product. Some considerations are whether the product is functional or a luxury item, and how colors can reflect their purpose or mystique and appeal to the gender that will use the item.

Glossary

Color discord Discordant colors are color combinations that contrast, clash, or "fight" rather than harmonize. Color discord can make the viewer uncomfortable, but it can be used to enhance the thematic content in a piece of art.

Color environment Color choices that reflect and enhance the function and mood of an interior or architectural space.

Color expression Color can function as the most expressive tool in art. Expressive color is a subjective, personal, cultural, or symbolic use of color in art or design.

Color symbols Color associations that stand for ideas and/or are culturally based, for example, red for sexuality and black for death.

Chapter 12

Color in Art

LEARNING OBJECTIVES

- For the student to connect color theory concepts to the use of color in art and design.
- The evolution of color in art, through media, historical context, and changing ideas about color in art.
- For the understanding of color's role as a primary language of expression in art and design.

INTRODUCTION

Color has been a critical component of art since prehistoric times. The role of color in art is always in flux, continuously shifting throughout art history. The artist uses color perceptually, symbolically, intuitively, expressively, and formally to create light and form illusion. Artists and art movements have altered and shaped the role of color in art history.

Human beings have used colored materials to make paintings and objects before written history, in 13,000 B.C. The function or rituals associated with the cave paintings of Lascaux, France, remain a mystery, but we have to admire the invention and resourcefulness of the artist(s). Red ochre, brown ochre, and manganese dioxide black pigment was applied with the fingers or sprayed on the cave walls using a hand as a template. The Lascaux paintings are a lively depiction of bisons, horses, and men. Most amazing, perhaps, is the evidence of man's compulsion to make art, which was akin to making magic. We share the inner drive to create art with our primitive ancestors.

REFLECTED LIGHT—MOSAICS

Color and symmetry were considered the foremost elements of art from ancient times through the medieval period. During this period, the principal aspect of color was believed to be value, due to the theories of Aristotle, in which he determined that all colors were a result of the mixtures between white (light) and black (darkness). In mosaics of the late medieval period and early Renaissance, color was also associated with precious stones, symbolic of wealth and spirituality. The reflective colors of glass, stone, gold, and silver were their most prized materials because of their qualities of reflecting and redirecting light.

Mosaic is a type of painting made with small pieces of stone, glass, or ceramic that is built onto a wall to become an integral part of architecture. [12.1] The mosaic shown here is the ceiling of the baptistry in Florence, Italy. The baptistry was a Roman building constructed in the fourth or fifth century. The beautiful ceiling mosaic was added later, from about 1225 to the early fourteenth century. The mosaic depicts the Last Judgment portraying a large figure of Jesus paired with scenes of the Devil and the torments of damned souls. Despite its dark subject, the sparkling surfaces of the mosaic ceiling and its artistry of design have an overwhelming beauty. Medieval and early Renaissance mosaics made use of optical mixtures to formulate complex color relationships and iridescence. Candle and lamplight reflected from the uneven surfaces of mosaics on church ceilings and apses make the walls sparkle and bring them to life. Mosaics made the belief in divine light tangible through incredibly detailed images depicted with iridescent glass tiles made by encasing gold or silver foil inside transparent glass cubes. The color in these mosaics is mainly iconographic: gold, silver, and white depict divine light; blue

Figure 12–1 Interior of the cupola of the Baptistry, Florence, Italy. Photo credit: Nicolo Orsi Battaglioni/Art Resource, NY. Mosaics reflect actual light off the tile surfaces to symbolize divine light.

symbolizes the celestial or the heavens; and purple indicates royalty. In the design of mosaics, colors are modulated by slight color variations of tiles in close proximity; these modulations form optical mixtures. Pure colors were equated with jewels, representing the preciousness of the Christian image. Jewels were thought to contain light and expressed the highest aesthetic in Christian art, divine power. The Gothic period of Christian art continued this tradition by transmission of colored light through divine images depicted in stained-glass windows.

PRIMACY OF FORM—THE RENAISSANCE

Renaissance Frescos—Masaccio

The European Renaissance spanned a wide period of time and range of geography, covering approximately the years 1400 to 1560 in Northern and Southern Europe. Early Renaissance painting in Italy was characterized by innovation: the correct depiction of forms in space; the employment of perspective, which had recently been developed; and classical ideals. The artist Maso di Ser Giovanni di Mone Cavasi, known as Masaccio (1401–1429), was an innovator in all these developing areas of painting. Masaccio used the concepts of perspective and architectural style of Brunelleschi, the designer of the dome of Santa Maria del Fiori in Florence and one of the principal inventors of the science and art of perspective.

The fresco shown here, *The Tribute Money* [12.2], is located inside the Brancacci Chapel in Florence, Italy. Masaccio worked on this fresco in collaboration with an artist named Masolino but left the project in 1427, and the works were completed in the 1480s by Fillippino Lippi. The Chapel is dedicated to St. Peter, and many of the paintings represent stories about his life. *The Tribute Money* tells the story of Christ and his disciples entering a Jewish temple and being asked for money by a tax collector. Christ asks St. Peter to go to the sea and bring the first fish that he catches. Peter does this, and the first fish he catches has a coin in its mouth that is worth double the amount needed for the Temple tax and is given to the collector. Masaccio illustrates this story with the three main events occurring simultaneously in one painting: Jesus charging Peter, Peter fishing, and the payment of the money.

There are advances in this painting that are forerunners of the high Renaissance style. The background elements are characterized by the use of linear perspective in depiction of architecture, the diminishing sizes of the trees, and the atmospheric perspective of the distant mountains. Some of these details were made more evident by the cleaning of the fresco in 1981–1991. For instance, there were gold leaf halos on the saints and Christ that had chipped off over time. The halos were consistent with the concern for the correct depiction of objects as they are also in believable perspective and have since been restored to the fresco.

During the Renaissance, art guilds controlled the quality of pigments for the execution of commissioned paintings. When a painting was commissioned, specific top-quality pigments could be requested and provided by the art patron. Red and vermilion were the most expensive pigments and dyestuffs, so only important personages were represented wearing these colors. Masaccio also used his colors in an inventive manner for his time, creating strong form and volume by color modulations. He also formed illusionary light and shadow, including use of complementary colors to create shadows on the green drapery with red.

During the Renaissance, color was subject to form. Form, line, and the volumetric aspect of an image reigned over color, thought of as merely a decorative element of art. Form was regarded as a masculine art element and color as a feminine art element. This notion was based upon the classical archetype of Greek sculpture, idealized at this time. Greek sculpture marbles, originally polychromed, were only known during

Figure 12–2 *The Tribute Money,* Masaccio (Maso di San Giovanni). Brancacci Chapel, S. Maria del Carmine, Florence, Italy. Scala/Art Resource, NY. This early Renaissance fresco was groundbreaking in its depiction of space and innovative use of color to express volume.

the Renaissance as pure white. This idealization of form influenced a prevalent attitude in Western art toward color as a frivolous component of art.

LIGHT AND MOVEMENT—THE BAROQUE

Caravaggio

The Baroque period of Western art spanned the late sixteenth century through the seventeenth century. Movement of figures and drapery in space and potent light/dark value contrasts are the hallmarks of the Baroque period of painting. The naturalistic high-contrast lighting of forms is called *chiaroscuro.* A *luminist* strategy in painting emphasizes the color effects of light. Several artists of this time employed the luminist approach of chiaroscuro, including Rembrandt van Rijn and Georges de La Tour [10.19]. Michelangelo Merisi, an Italian artist commonly called Caravaggio (1573–1610) after his birthplace, rendered scenes from the Christian gospels with unparalleled naturalness and realism. A principal theme of his paintings is light itself, which subtly indicates the presence of God. Caravaggio did not employ older devices to convey spirituality such as halos or gold-leafed surfaces. Instead, he plunged his figures into a dark space with narrow depth and illuminated the scenes with dramatic, harsh light and shadow. In Caravaggio's *The Calling of St. Matthew* (1607), we see Christ "calling" St. Matthew (the Roman tax collector) to be his disciple. [12.3]

Figure 12–3 *Calling of Saint Matthew* (1599–1600), Caravaggio (Michelangelo Merisi da). Photo: Mauro Magliani. Alinari/Art Resource, NY. Caravaggio used chiaroscuro, a dynamic light/dark contrast, to dramatize his subjects.

The scene depicts Matthew counting coins at a table next to a young boy encircled by onlookers in the contemporary dress of Caravaggio's time. Caravaggio depicts Christ as a shadowy figure on the right, his gesture pointing toward Matthew, who, in turn, points toward himself. This lends a rhythm to the direct yet subtly depicted message of the painting. Caravaggio directs light to convey divine power. This light emanating from the right darkness is pierced by a shaft of light not directly from the person of Jesus, but from behind him, in a strikingly contemporary manner. The light source illuminates key sections of figures and faces, mainly on the boy and Matthew, as an indicator of the light of God. The drama of the painting is provided by its high light/dark value contrast, which indicates the principals in the story. The "gloomy darkness," called *tenebrism*, is the manipulation of light and color to heighten the narrative of the painting.

POETRY IN COLOR—ROMANTIC PERIOD

Joseph Mallord Turner

From the late 1600s onward, artists were influenced by the discoveries of Newton and later by the color theories of Goethe. The art of the Romantic period, from the late 1700s to the 1860s, involved human emotions, man's relationship with nature, and self-expression. The English painter Joseph Mallord Turner (1775–1851) was a luminist and a color innovator. Turner's paintings were a documentation of history and a unique depiction of dramatic light, as in the painting *The Fighting Temeraire* (1839). [12.4] This painting signifies color as light, space, time, and atmosphere. Turner achieved luminosity by the

Figure 12–4 *The Fighting Temeraire* tugged to her last berth to be broken up (1838, 1839), Joseph Mallord William Turner. Oil on canvas, 90.7 cm. × 121.6 cm. Turner bequest, 1856 (NG524). National Gallery, London/Art Resource, NY. Turner's paintings created color atmosphere by brushwork and subtle gradients of hue and value.

progression of sequential mixtures from hues to gray. His style of painterly marks accentuated the nearly formless areas of color, particularly in the images of skies and waters in his paintings. Turner seems to have adopted Goethe's prejudice to warm colors as positives and cold colors as negative forces in his pictorial strategy.

Turner's work is sometimes considered to be a precursor to the art movements of Impressionism and Abstraction; however, he was not only interested in formal color manipulations, but also in great romantic themes. While Turner's paintings are luminous depictions of light, his themes celebrated monumental ships, mythology, and architecture of the past. Turner's romantic philosophy of painting motivated him to increasingly merge his subjects with pure color, demonstrating the spirituality of nature. Turner employed both luminist and colorist strategies in intuitive and theoretical color combinations. His paintings reflect the writings of Goethe, who said "from these three: light, shade and color, we construct the visual world," through his use of cool and warm colors. He also acknowledged Newton in his recognition of color as a component of light.

TIME AND PLACE—IMPRESSIONISM

Claude Monet

The Impressionists were directly engaged in a formal study of color and light. Several factors led to the Impressionist's stylistic and colorist developments. By the late nineteenth century, the artist's physical studio became portable, because of the availability of artist's colors in tubes. This portability allowed artists to work outside on the actual site of the landscape. Cheveruel's writings on simultaneous contrast and optical mixing had an enormous influence on Impressionist painting. The advent of photography was also a factor in transforming the role of artists from recorders of reality to creators of a more subjective, expressive art.

The French Impressionist painter Claude Monet (1840–1926) was both a great colorist and color innovator. [12.5] His work parallels the Impressionist stratagem, conveying the fleeting effects of light and weather on a particular time and place. Monet's "objective" observations of color and his painting work on site (plein air) were often subjectively finished in the studio. Theoretically, his small marks of color could form optical mixtures; however, Monet's paint application was more painterly than either Seurat's or Pissaro's. Monet's marks unite with his forms in a light and tenuous manner. Upon close inspection, Monet's paintings are essentially an abstract array of marks, a fact that shocked viewers of his time.

In his specification of color to the quality of light, Monet is a pure colorist. Tints of cool and warm hues are woven together to formulate light, temperature, and a particular time and place. With only spectral hues on his palette, Monet broke with the past tradition of earth colors. His late paintings of water lilies forged new territory that moved toward completely unfettered color. In the series of paintings of Rouen Cathedral, Monet explored optical mixtures and direct observation of sunlight, diffused light, shadow, and atmospheric effects on the same subject, the famous cathedral's architectural forms, to indicate the temporal nature of light on objects. This series, executed from 1892 to 1894, was painted by Monet in rooms that he rented with a direct view of the cathedral. Cumulatively, this series of works directly indicates the fascination that the Impressionists had with optical mixture and the subjective and ephemeral nature of color through the filter of human observation and perception.

SIMPLE ELEGANCE—JAPANESE ART

Woodblock Prints

Japanese art emphasizes balance, color, and a strong compositional aesthetic. Areas of flat color emphasize the graphic quality of both Japanese prints and screens from the eighteenth and nineteenth centuries. In Asian art, shape and line are dominant over both

Figure 12–5 (a) *Cathedral at Rouen,* Evening (1893–1894), Claude Monet. Pushkin Museum of Fine Arts, Moscow, Russia. Scala/Art Resource, NY; (b) *The Cathedral at Rouen,* In the Fog (1893), Claude Monet. Oil on canvas, 100 cm. × 70 cm. Folkwang Museum, Essen, Germany. Erich Lessing/Art Resource, NY. Monet broke ground through a palette of spectral colors and small marks of color that mix optically. These two works are from a series of paintings that depict the changeable lighting effects on Rouen Cathedral.

color and form. Color masses are either flat or textured but always have highly structured contours. The preferred harmonies of Japanese color can be either contrasting complements or analogous hues, in addition to black, white, and red. The neutral black and white aesthetic stems from traditional ink paintings and calligraphy, which emphasized line and mark. Japanese ink paintings have sensitive modulations of light and dark that are not quite as apparent in the color prints and screens.

The woodblock print *Pilgrims at Kirifuri Waterfall on Mount Kurokami in Shimotsuke Province* by Katsushika Hokusai exemplifies the refinement and stylization of Japanese woodblock prints. The dynamic force of the waterfall enhances the graphic flatness of color and linear quality of this image. Hokusai moved away from the traditional woodblock print subjects of Kabuki Theater and geishas and went on to explore the landscape of the Japanese provinces. The stylized waterfall moves downward through the picture in a branchlike structure flanked by the pilgrims who quietly view the natural phenomenon. This print has the signature bold graphic quality of Hokusai's best works. The colors create an interlocked pattern of contrasting white and dark along with gentler gradations of yellow-green and yellow-orange to make a simultaneously striking and soothing color harmony. The flat areas of color function as design elements, contrasting with Western color usage of the time, which used color to depict light, form, and atmosphere. When the United States commenced diplomatic and trade relations with

Figure 12–6 *Pilgrims at Kirifuri Waterfall on Mount Kurokami in Shimotsuke Province* (1831–32), Katsushika Hokusai. Color woodcut, 14 13/16" × 10 1/8" inches (37.7 × 25.7 cm). The Samuel S. White 3rd and Vera White Collection, 1958. The Philadelphia Museum of Art/Art Resource, NY. The Japanese refined the art of relief printing in their polychrome woodcut prints. These prints were instrumental in a new approach to color in Western art.

Japan in the late nineteenth century, Japanese art was a revelation to Western artists. The impact of Japanese art on Western art was highly influential on developing modern styles. [12.6]

COLOR EXPRESSION—NEOIMPRESSIONISM

Van Gogh and Gauguin

The influence of Japanese art on the Neoimpressionists Vincent van Gogh (1853–1890) and Paul Gauguin (1848–1903) was profound. Van Gogh's approach to color was revolutionized by his exposure to Japanese art. Gauguin and Van Gogh were equally influenced by both the linear quality and juxtaposition of flat, colored areas in Japanese prints. Postimpressionism, or Neoimpressionism, is a loose category for a highly individualized group of artists that includes Georges Seurat, Paul Cézanne, and Toulouse Lautrec, whose work succeeded Impressionism.

Gauguin and van Gogh, who lived together for a time, sought to revolutionize art through a fresh approach to color. Van Gogh "drew" his color onto the canvas with individual linear marks and highly saturated complementary hues, which accentuated the expressive quality of his subjects. The visual force in van Gogh's painting results from his aggressive color application with thick impasto paint. [11.7] Van Gogh's mode of expression can be partly attributed to his place in the history of painting materials, as

Figure 12–7 *What, You Are jealous?,* Paul Gauguin. Pushkin Museum of Fine Arts, Moscow, Russia. Erich Lessing/Art Resource, NY. The paintings of Gauguin employed a dual color strategy, partly tonalist in his subtle color shadings of the human figure and partly engaged with pattern-like flat areas of subjective color.

the availability of thicker consistency tube colors and the expansion of the artist's color palette with new pigments and dyes factor into his painting style. The physicality of his textured surfaces emphasizes color contrasts in a dramatic fashion. Instead of painting his subjects in local colors, van Gogh employed imaginative color as an indirect mode of thematic communication. The color freedom investigated by both van Gogh and Gauguin represents a shift in Western painting tradition; non-Western cultures had color traditions without the color inhibitions of European and American painting.

Paul Gauguin also was attracted to the dramatic "flat" effects that he observed in Japanese art and in the sculptures and motifs of Tahiti, where he lived his later life. Despite his interest and use of flat color, Gauguin employed tonalist nuances of color in many of his paintings. A *tonalist* applies subtle tonal steps in a narrow range of hues to create volume. Gauguin lived in Tahiti for several extended periods of time beginning in 1891. His desire to live a primitive life devoid of Western culture motivated his artistic growth. In this painting, *What, You Are Jealous?*, both of Gauguin's painting strategies are in play, the background is built from flat, vivid color, and the figures are modeled in subtle tonal and color temperature gradations. [12.7] Gauguin painted this piece in Tahiti, where he explored not only the local culture and spiritual beliefs, but everyday activities, hopes, and fears of indigenous people, primarily women. This work captures a moment of conversation between two women, one of his preferred subjects.

Gauguin's work showed the strong influence of what was thought of as "primitive" art in his time, the art of Egypt, Asia, and India. Van Gogh and Gauguin released color from representation and utilized it for self-expression.

FAUVISM AND BEYOND

Henri Matisse

In his youth, Henri Matisse (1869–1959) was affiliated with the Fauves, a group of young French painters. The Fauves were known as the "wild beasts" because of their vivid colors and distortions of reality in their paintings. [12.8] Fauvism established an expressive colorist tradition in French painting. Henri Matisse's early paintings of faces and figures were modeled with very saturated contrasts of cool and warm color. Later in his career, he introduced flat color into his paintings, and line, color, and shape became his primary elements. The fresh, direct quality of his paintings unsettled viewers of his time. The quality of direct, pure, saturated colors painted in a spontaneous manner is the same feature that attracts us to his art today. Matisse freed color from depiction and form saying, "I cannot copy nature in a servile way; I am forced to interpret nature and submit it to the spirit of the picture." His joyful paintings have a color resonance due to

Figure 12–8 *Interior with Egyptian Curtain* (1948), Henri Matisse. Oil on canvas. 45 3/4" × 35 1/8"; 116.205 × 89.2175 cm. Acquired 1950. The Phillips Collection, Washington, D.C. © 2011 Succession H. Matisse/Artists Rights Society (ARS), New York. Matisse used expressive, flat color to project a theme of ease and joy.

the transparent, almost watercolor-like surfaces of his oils. The decorative, flat colors of his subjects—figures, foliage, and themes of the joyful essence of life—led to his later colored paper cutouts, which are the distillation of his work.

CUBISM - FRACTURING SPACE

Braque

Cubism was a style that began at the advent of the 20th Century. Two principal artists, Pablo Picasso (Spanish, 1881–1973) and Georges Braque, (French, 1882–1963) working closely in Paris, in 1907–1914 developed the paintings' hallmarks, a type of fracturing of subjects and spaces into cube- like forms incorporating multiple viewpoints. Both artists were also proponents of a type of primitivism, influenced by Non Western art such as African masks. The principal motivation behind this approach was a rejection of art that simply copied nature and an embrace of the essential two- dimensionality of painting.

The early Cubist paintings that resulted from these ideas have shallow spaces and a type of figure/ground ambiguity, in which the subjects cannot be discerned from the negative space. Interestingly, the subjects of these early Cubist works are somewhat traditional; still lives and figures that are configured, however, into angular forms that virtually fill the entire picture plane. The paintings became sequentially more abstracted and complex, reaching a period of "analytic Cubism" in 1911, comprised of gradated planes and forms broken into many faceted rectilinear shapes. During this period, an achromatic palette was used, based primarily on blacks, whites, grays and browns. The works further evolved through the use of actual paper, called papiers collés, which we now know as collage, often incorporated into the paintings. The work shown here by Braque, *Fruit Bowl and Two Playing Cards*, is a painting that appears to be a collage, the cubist forms resolving themselves into the appearance of cut paper. [12.9] The objects are weightless and distributed throughout the composition in a rhythmic fashion, making the most of the achromatic color scheme to depict gradated spaces and a playful geometry of form.

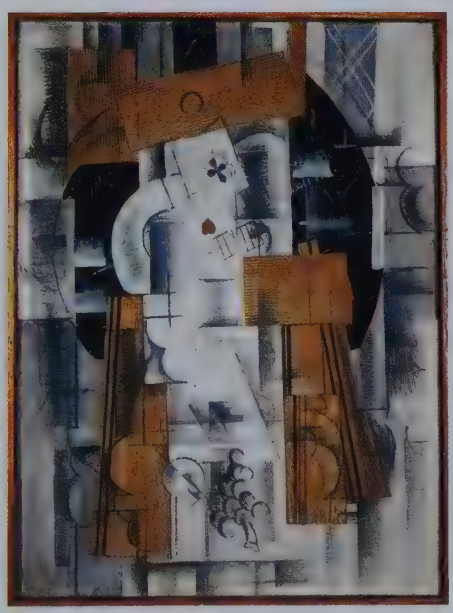


Figure 12–9 *Fruit Bowl and Two Playing Cards* (1913), Georges Braque. Crayon, charcoal and oil on canvas, 81 cm. × 60 cm. Inv. AM2701P. Photo: Jacqueline Hyde. Musee National d'Art Moderne, Centre Georges Pompidou, Paris, France. © 2011 Artists Rights Society (ARS), New York/ADAGP, Paris. Art Resource, NY. The Cubists often employed a limited, almost neutral palette of colors that built broken, gradated forms.

COLOR UTOPIANS—MODERNISM AND PURISM

Le Corbusier

Modernism began in the early twentieth century and reached an early-century culmination in the Bauhaus School, a pre–World War II art school in Germany. Modernism sought to put aside the traditions of art in favor of a newer, purer form of utopian art.

There was a strong reaction to the chaos of World War I, which manifested itself in simplicity of approach in both art and architecture. Both De Stijl (The Style) in the Netherlands and the Bauhaus sought to create an international visual language that transcended any cultural differences.

Charles Edouard Jenneret, a painter, in collaboration with Amedee Ozenfant, formed another modernist group in Switzerland called the Purist style. Later, Jenneret changed his name to Le Corbusier (1887–1965) to reinvent himself and pursue architecture and urban planning. Le Corbusier had a vision for a completely new urban infrastructure of skyscrapers to replace the old, cramped, noisy, and dirty city housing with which he was familiar. He envisioned a clean, new, organized urban plan that would solve the problems of crime and class disparity. All of the modernist movement shared a belief in classicism of form, and an uncluttered, spare, and functional approach to design and art, stripped down to its most essential elements. Modernism thus set up a dichotomy between Expressionism and formalism. The color aesthetic of modernism also reflected these austere, yet elegant values; often color was refined to the three subtractive primary hues and the two essential neutrals of black and white.

The building shown here, *Centre de le Corbusier* [12.10], is a museum Corbusier designed to house his paintings and graphic works in 1963. Interestingly, this turned out

Figure 12–10 *Centre Le Corbusier,* Howard Davis. © 2011 Artists Rights Society (ARS), New York/ADAGP, Paris/F.L.C./ Artifice Images. The modernist aesthetic of clean form and pure color is evident in this museum of Le Corbusier's artwork.

to be the last building that Le Corbusier designed. The Centre le Corbusier, Heidi Weber Museum, has many of the characteristics of the Purist style. The museum is located on the shores of Lake Zurich, Switzerland, and is made of prefabricated steel, glass, and multicolored enameled plates. The roof of the complex is a free-floating structure of triangular forms. Le Corbusier boldly uses pure, modernist primary hues and white on the outside of the building. Inside, there is a great deal of natural wood paneling, white walls, and a tremendous amount of light to illuminate Le Corbusier's colorful, abstract paintings and graphic works. The color demonstrates a sparkling side to the austere modernist "white" aesthetic.

The modernist aesthetic was both rational and antiorganic, its color aesthetic of purity persisting into and beyond the first half of the twentieth century. Modernism viewed color as an aesthetic ornament that should be controlled. This attitude harkens back to the Renaissance notion of color as a foreign, feminine element of art.

The Delaunays

Robert (1885–1941) and Sonia Delaunay (1885–1979), the French artists previously discussed in Chapter 4, were part of the modernist movement concerned with the exploration of color and its effects. Robert Delaunay made paintings in which he used the concept of *simultaneé* (simultaneous contrast) to create color dynamics and movement. His paintings were, in part, a reaction to the works of Seurat, whose small dots and dashes of complementary hues were meant to scintillate but at times instead formed chromatic neutrals by optical mixture. Sonia and Robert Delaunay both worked on paintings that employed larger areas of complementary colors, to maintain their separation, hence creating a contrast of color dynamics and vibration. [4.5] The paintings are composed with sun- and moonlike colored discs juxtaposed in intersecting circular rhythms. The objective of these works was to achieve a color effect called luster, a type of optical mixture in which colors blend imperfectly to create a sparkle or glimmer.

PIERRE BONNARD—PREMIER COLORIST

The paintings of Pierre Bonnard (French, 1867–1947) have been associated stylistically to the nineteenth rather than the twentieth century. This conception stems from the superficial perception of his work as being Impressionistic in style, which also omitted his work from being part of the mainstream in modernist European painting. Bonnard's paintings seem to elude categorization. In his twenties, Bonnard was a strong colorist, part of a group of artists called the Nabis, who desired to formulate color into mood. A *colorist* is an artist that has an interest in color contrasts and interactions applied for formal and/or expressive purposes.

Bonnard's later paintings show "qualities of daring" (the critic John Russell) that were conceptually on a similar level as the inner worlds portrayed by the Surrealists. [12.11] Bonnard's subjects—domestic life and nudes—are really explorations of the sensation of light, in which he represents the complexities in our perception of color. Bonnard's paintings are a visual challenge to modernism in their engagement of the "feminine or other" realm of color. He was not interested in the masculine deconstruction of form that was at the center of modernism. Bonnard's approach to painting was a synthesis of symbolism and impression. Unlike Impressionism, the paintings seem to occupy memory rather than being made from perception. The spaces in his paintings are defined by color, distorting traditional ideas of depth and making the forms fluctuate. Bonnard flattened and completely rethought space in his paintings through a visual language of pattern, weaving a tapestry of colored marks. Bonnard unifies a wide number of hues, saturation, and color temperature shifts seemingly without effort. His highly pitched colored saturation is visually exuberant yet thematically melancholic.

Figure 12–11 *La terrace a Vernon* – The terrace at Vernon (Bonnard's country house), Pierre Bonnard. Canvas. © 2011 Artists Rights Society (ARS), New York/ADAGP, Paris. Erich Lessing/Art Resource, NY. Bonnard demonstrated his ability as a colorist through his tapestry-like patterns of color.

INNER LIGHT—ABSTRACT EXPRESSIONISM

Helen Frankenthaler

Abstract Expressionism, the first American art movement, came into the forefront of world art as a style in the late 1940s through the 1950s. The Abstract Expressionists returned to the instinctive color of Expressionism, putting aside the theoretical approach of modernism in favor of subjectivity. In Abstract Expressionism, the automatism of Surrealism was used to create large-scale paintings that were expressive, abstract in form, and indicative of the painting process itself. Jackson Pollack, William de Kooning, and Mark Rothko, among others, further released color from form and shape, using marks and drips to record the encounter of artist and canvas.

Helen Frankenthaler (1928–) is one of the later painters affiliated with this movement. Frankenthaler's works from the 1950s were canvases stained with oils thinned with solvent. Frankenthaler was influenced very strongly by the work of Jackson Pollack and his instinctive method of working. Pollack's later works were often stained canvases, paintings on raw, unprimed canvas. Frankenthaler's paintings, produced by staining, have a flowing quality; the colors seem to bloom from the canvas. Frankenthaler's works are abstract but are often distillations of nature. Her colors are personal, delicately nuanced, but her forms are bold in scale.

The piece shown here, *Interior Landscape* [12.12], has, like many of Frankenthaler's works, colors derived from the landscape wedded with abstract form. In this case, her color choices run parallel with the concept of landscape, with their greens and yellows "framed" against a pure cerulean blue space. The framing device operates metaphorically, producing an interior area, which is analogous to a personal region of thought or memory. Helen Frankenthaler is, like the Abstract Expressionists, indebted to the concepts of the Surrealists, whose automatic drawing and painting was directly linked to unconscious thought.

Figure 12–12 *Interior Landscape* (1964), Helen Frankenthaler. Acrylic on canvas, 104 7/8" × 92 7/8" (266.38 cm × 235.9 cm). © 2011 Helen Frankenthaler/Artists Rights Society (ARS), New York. San Francisco Museum of Modern Art – gift of the Women's Board.

Frankenthaler's juxtaposition of color resonates emotional states, rather than formal color relationships. In this way, color in the twentieth century gained even a greater independence from the identity and depiction of objects.

COMMERCIAL COLOR AND CULTURE

Andy Warhol

Andy Warhol (American, 1928–1987) is one of the most influential art figures of the twentieth century; his work is a commentary on cultural commodity. His art points to the way that Americans are targets for mass marketing of products, people, and ideas. Warhol's experience as a graphic artist informed all aspects of his paintings and prints. His color aesthetic was more indicative of commercial packaging color than being rooted within the tradition of painting. Warhol used silkscreen as a principal medium, which was primarily a commercial process at the time when he started his mature works in the 1960s. This printing process allowed him to produce his trademark photographic images that are underlaid with strong, often fluorescent colors in striking yet elegant combinations. Warhol's works are based on his principal idea that U.S. culture is glutted with information, and the public experiences many events only through the media of TV and print. When the public is bombarded with images such as consumer goods, celebrities, and new events, these images lose impact and yet become iconic by their very repetition. These blank or consumer images are then appropriate to become cultural currency, a type of image sans emotion. The role of color in his work is twofold in his seemingly arbitrary combinations—for instance, in the face of a movie icon like Marilyn Monroe, both celebrating her emblematic power while also flattening her face into a formal motif.

His color style reflects contemporary art's movement away from the tradition of painting with artist's pigments toward a color aesthetic with a commercial, graphic look. [5.18]

LIGHT REFLECTED—MINIMALISM AND BEYOND

In the late 1960s and the 1970s, two U.S. art movements followed Abstract Expressionism and Pop art, namely minimalism and Op art; see [4.28]. These styles are collectively known as Post-painterly Abstraction, which revisited modernist ideals of formal color and composition. These styles refined the earlier modernist ideas to their essentials; the subjects for minimalism and Op art were generally nonobjective, involved with pure, geometrically based shapes and lines. Post-painterly Abstractionism was primarily concerned with formal visual relationships rather than with emotional or symbolic content.

COLOR AND CONCEPT—YVES KLEIN

The cover illustration by Tadasky, Japanese artist Tadasuki Kuwayama (1935–), is an example of Optical Art, also known as Op Art. Op Art explored vision itself, presenting the viewer with geometrically based optical illusions and color interaction effects. The paintings in this style often used carefully manipulated color gradations, vibrating complements, and subtle color tonalities, to create effective illusions of depth and movement. The Tadasky painting staggers primary colors, red, yellow and blue in concentric circles that progressively narrow in width toward the center of the circle. The visual effect is of a space that simultaneously recedes and advances in the center of the circle.

Many Op Art paintings used the color interaction presented by Albers' Interaction of Color. The Op Art style included such artists as Victor Vasarely, Richard Anuszkiewicz, and Bridget Riley. The Op art movement was at its peak in 1965, when there was an exhibition called The Responsive Eye, created by William C. Seitz at the Museum of Modern Art in New York City.

PIGMENT AND RITUAL—ANISH KAPOOR

Anish Kapoor's works address metaphysical opposites, presence and absence, solid and intangible. In the 1980s, he made groups of sculptures with forms distilled from symbolic objects. *As if to Celebrate, I Discovered a Mountain Blooming with Red Flowers* is an example of a work from this period. [12.13] This sculpture contains references to Hindu temples and rituals in Indian culture. The sculpture specifically refers to a myth of a Hindu goddess who was born from a fiery mountain made from the bodies of male gods. One of the principal formal and symbolic elements in this piece is the application of pure powdered pigment, which is flicked onto the surface of the sculpture in order to leave no trace of the hand. The powdered pigment gives the artist a rich, pure surface color that would be unattainable in another medium. Since it is fine powder, the appearance of the pigment imparts the piece with an ephemeral quality. This piece recalls rituals and the tradition of *arte povera* or "poor materials."

COLOR IN INSTALLATION AND IMAGE

Jennifer Steinkamp

The new media artist Jennifer Steinkamp's work cannot be readily categorized. Steinkamp's media is primarily projection video installation, often accompanied by sound. While her work is video, it is made from computer-generated images, some abstract and some real (what the artist calls "artificial nature") in various scales and methods of installation within architecture spaces. Sometimes the images are projected within

Figure 12–13 *As if to Celebrate, I Discovered a Mountain Blooming with Red Flowers* (1981), Anish Kapoor. 3 drawings and sculpture with wood and various materials, 97 × 76.2 × 160 cm, 33 × 71.1 81.3 cm. © 2011 Anish Kapoor/ARS, New York/DACS, London. Tate, London/Art Resource, NY. This sculpture by Anish Kapoor is covered with pure pigment that has an untouched quality.

a shape: on an architectural arch or into a dome. Often the pieces are projected onto sculptural layers installed in a given space. [12.14]

Steinkamp states that she "feel(s) a great responsibility to create an artwork that engenders poetic resonance." There is also an element of interactivity in many of these moving pieces of art. Often the videos are purposely designed so that the viewers' shadows will disrupt the images, leaving shadows on the projections. Also, some projections are made in several layers, and the viewers' shadows reveal secondary images because the projectors are located in multiple sources in the installations.

Color plays a large role in Steinkamp's work, which are computer animations imbued with variables like gravity, turbulence, and wind. The artist has stated that she has an interest in "lifelike" motion. The color in *The Wreck of the Dumaru* is sharply contrasting and striking along with being strongly significant to its theme. This piece is based on a true story from Steinkamp's family history. Her great uncle was on the crew of the ship *Dumaru* during World War I. The ship, carrying weapons and fuel, was struck by lightning and wrecked at sea. Steinkamp's uncle, then 19 years old, survived on a lifeboat for 13 days, during which he drank seawater, became hallucinatory, and died before he could be rescued.

The video presents two views of the ocean combined; the blue section is a view from above, and the orange/red section is a side view between the waves. The view from above represents our *idea* of the ocean, and the continuously undulating blood red wave is symbolic of the tragedy. The viewer is both engaged with the beauty and mesmerized by the endlessly changing "ocean."

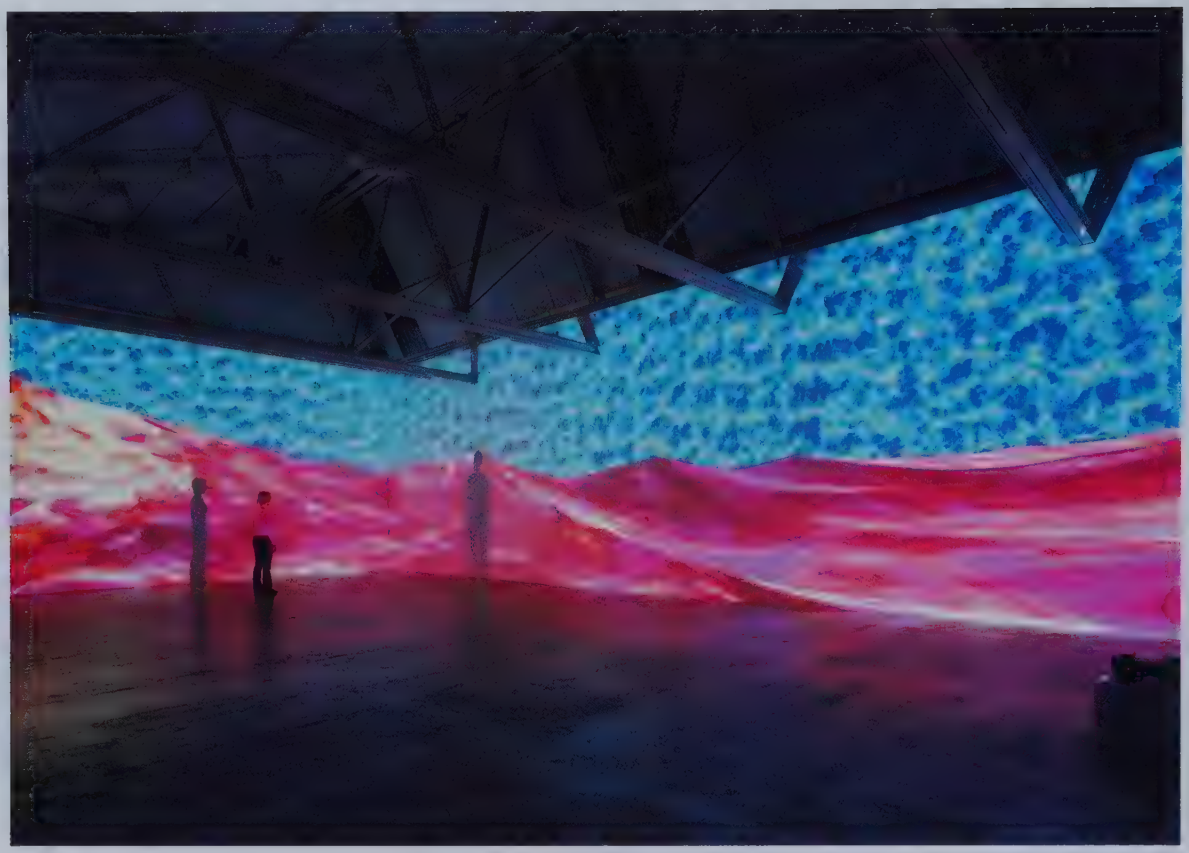


Figure 12–14 *The Wreck of the Dumaru* (2004), Jennifer Steinkamp. Projection 48' × 15' and 22' × 15', size variable, lumen projectors, computers. Photographer: Marcus Leith. The red surging wave in this video installation represents a story about the sea.

COLOR IN LIGHT AND SPACE

David Batchelor and Jim Lambie

David Batchelor is a British artist (1955–) who writes about and makes works that address the phenomenon of color. Batchelor explores color as an entity independent of art, focusing on its physical effects, meanings, symbology, and presence in a given space. His works take the form of sculptural installations that are deceptively casual: throwaway bottles infused with color, lit from inside and formed into hanging or freestanding colored structures, colored lights that glow from everyday objects and screens, with all of the wiring visible. Some of Batchelor's works are large-scale public installations, which use pure hues of colored light projected from objects. His book *Chromophobia* discusses the idea of color as a primitive and powerful element of art that is underrated, underused, and actually dismissed in the (Western) history of art.

Jim Lambie (1963–) is a Scottish artist who makes works from found objects that he transforms and uses to create installations that are of visually scintillating color. Lambie has made several versions of *Zobop* (shown on the cover), a floor installation of colored tape fitted and changed depending on the configuration of the floor of a gallery, room, or stairs. The patterns that Lambie generates with the tape installations and other found elements often create hue, value, and color contrasts so strong that they generate a striking visual movement. Like David Batchelor, he is fond of humble materials that represent the visual experience of color without the use of technology. His works are process based, transforming both a space and the viewer. The artist thinks of these

Figure 12–15 In this installation by two artists, Jim Lambie and David Batchelor, each approaches pure colors as a means of altering a space, through rhythmic pattern (Lambie) and found technological components that project colored light (Batchelor). *Zobop* (1999–2003), Jim Lambie. Multicolored vinyl tape. Courtesy Sadie Coles HQ, London, and The Modern Institute, Glasgow. *The Spectrum of Brick Lane* (2003), David Batchelor. Stell shelving, found lightboxes, fluorescent light, acrylic sheet, vinyl, cable, plugs and plugboards. Courtesy Anthony Wilkinson Gallery, London. Exhibition installation, "Days Like These," at the Tate Gallery, 2003 © 2011 Artists Rights Society (ARS), New York/DACS, London. Tate, London/Art Resource, NY.

installations as psychological spaces, which are rhythmic and abstract, with hints of the world through the inclusion of transformed objects. Lambie's works engage the visual sense as well as suggest the visual music formed by the brilliant color contrasts. [12.15]

Artists have been colorists throughout the span of all periods, media, styles, and locations in art history. Artists have embraced color as a central part of their emotional, symbolic, formal, and structural language.

Glossary

Tenebrism A more extreme form of chiaroscuro, which utilizes very strong or dominant areas of dark-value colors in high contrast with lights in a composition.

Tonalist An artist that uses tones, subtle modulations of color, to add form, atmosphere, or nuance to a work of art.

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